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Scope for Human-Induced Mortality in the Context of Atlantic Whitefish (*Coregonus huntsmani*) Survival and Recovery

Niveau de tolérance de mortalité anthropique du corégone atlantique (*Coregonus huntsmani*) en regard de sa survie et de son rétablissement

R.G. Bradford[1], H. Schaefer[1], and G. Stevens[2]

[1]Department of Fisheries and Oceans
P.O. Box 1006
Dartmouth, Nova Scotia, B2Y 4A2

[2]Department of Fisheries and Oceans
P.O. Box 1035
Dartmouth, Nova Scotia, B2Y 1J3

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ABSTRACT

Atlantic whitefish (*Coregonus huntsmani*) were known historically to occur in the Tusket-Annis and Petite rivers in Nova Scotia. The Tusket-Annis population was anadromous and is no longer present. The Petite Rivière population is lake-resident within the 16km^2 aggregate area of Minamkeak, Milipsigate and Hebb lakes on the Petite Rivière. A suspected anadromous run on the Petite Rivière is no longer viable. A recovery strategy has been developed which includes restoration of the species to its former range as a key objective. Assessment of allowable harm therefore requires consideration of the level of human-induced mortality that would not jeopardize survival or recovery currently or in the future as restoration efforts are initiated. Accordingly, both current and future potential sources of human-induced harm to Atlantic whitefish were identified by Fisheries Management, Habitat Management and Science branches of the Department of Fisheries and Oceans. The mechanisms through which the activity could impact on Atlantic whitefish was described. Because data to support quantitative assessment of the maximum human-induced mortality are not available, each activity was assigned a relative rank effect on survival or recovery. Measures that could be taken to mitigate the effects of the activity are proposed.

The weight of accumulated evidence indicates that the mortality arising from all human activities occurring within the area of the Petite Rivière currently occupied by Atlantic whitefish does not threaten their survival or recovery.

There is uncertainty that additional human-induced harm could be sustained by Atlantic whitefish within their current area of occupancy. Therefore, there is no scope for incremental increase in human-induced harm beyond current levels.

RÉSUMÉ

Le corégone atlantique (*Coregonus huntsmani*) était autrefois retrouvé dans les rivières Tusket-Annis et Petite, en Nouvelle-Écosse. La population de la Tusket-Annis, anadrome, a maintenant disparu, tandis que celle de la Petite, limnicole, est confinée à la superficie totale de 16 km^2 des lacs Minamkeak, Milipsigate et Hebb, éléments du réseau hydrographique de cette rivière. Une remonte anadrome présumée dans ce cours d'eau n'est plus viable. Un plan de rétablissement propre à l'espèce a été élaboré, qui comprend son rétablissement dans son ancienne aire de répartition à titre d'objectif clé. Une évaluation des dommages admissibles requiert donc que l'on considère le niveau de mortalité anthropique qui ne compromettrait pas sa survie ou son rétablissement à l'heure actuelle ou à l'avenir à mesure que des efforts de rétablissement sont déployés. En conséquence, Gestion des pêches, Gestion de l'habitat et Sciences ont identifié les sources actuelles et futures de dommages anthropiques au corégone atlantique et décrit les mécanismes par lesquels l'activité en cause pourrait avoir une incidence sur l'espèce. Comme des données ne sont pas disponibles pour faire une évaluation quantitative du niveau maximum de mortalité anthropique, un ordre de grandeur relatif de l'effet sur la survie ou le rétablissement a été assigné à chaque activité. Des mesures qui pourraient être prises pour atténuer les effets de l'activité concernée sont proposées.

La force probante des preuves accumulées indique que la mortalité totale imputable à l'ensemble des activités menées dans la région de la rivière Petite où se trouve le corégone atlantique à l'heure actuelle ne constitue pas une menace à sa survie ou à son rétablissement.

Étant donné qu'il est toutefois incertain si le corégone atlantique peut supporter d'autres dommages anthropiques dans sa zone d'occupation actuelle, une augmentation des dommages anthropiques au-delà des niveaux actuels ne peut être tolérée.

INTRODUCTION

The Atlantic whitefish (*Coregonus huntsmani*) was originally declared endangered in 1984 by COSEWIC and again in 2000. They are listed and protected as endangered under the Canada *Species at Risk Act* (*SARA*). The *Act* authorizes competent Ministers to permit otherwise prohibited activities affecting a listed wildlife species, any part of its critical habitat, or the residences of its individuals. Section 73(3) of *SARA* establishes that the permit can only be issued if the following conditions are met:

1) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted

2) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals, and

3) the activity will not jeopardize the survival or recovery of the species

An evaluation framework, consisting of three phases has been established by the Department of Fisheries and Oceans (DFO) to allow for determination of whether or not *SARA* permits can be issued. Briefly, species status, trends and recovery targets, and timeframe, are assessed in Phase I to determine if recovery is possible under conditions where human-induced mortality is greater than zero. If the outcome is negative then no permits would be issued. If the outcome is positive then an assessment of scope for harm arising from human activities is required (Phase II) and specific options for those activities, which would be consistent with the provisions of Section 73 (*SARA*), are determined (Phase III).

The Phase I assessment for Atlantic whitefish (Bradford et al. 2004) concluded that recovery was possible under conditions where human-induced mortality was greater than zero. Accordingly, this document determines the scope for harm to Atlantic whitefish arising from specific human activities, as well as the options available to minimize the likelihood the activities would jeopardize either survival or recovery.

Consideration of several factors, either contributing to the endangered status of Atlantic whitefish, or associated with the nature of the information available to support an assessment of allowable harm, is required to offer context to the basis for the Phase II and Phase III assessments. First, pronounced reduction in area of occupancy is a principle underlying cause of the endangered status of Atlantic whitefish. Known historically to occur in the Tusket-Annis and Petite river drainages (Fig. 1), the species is now restricted to the Petite Rivière, wherein life-cycle closure is a certainty only for a population resident within the 16km^2 combined area of Minamkeak, Milipsigate and Hebb lakes (Bradford et al. 2004)(Fig. 2). Range extension beyond the currently occupied three lakes within the Petite Rivière is therefore an important recovery objective. As such, some human activities likely to induce harm will only become an issue once efforts to extend the range of the species are initiated. Activities potentially impacting on the lake resident population therefore represent only a subset of all human activities requiring assessment. Therefore, current and future scope for harm arising from human activities are addressed separately throughout this document.

Second, neither age or stage structured abundance data or relative indices of abundance are available to support quantitative assessments of mortality to Atlantic whitefish arising from specific human activities. ‘Harm’ can only be assessed in a relative sense, i.e., what is the likely relative rank effect on survival or recovery of a particular activity in relation to the suite of human activities under assessment.

The term “mortality” is used throughout the document to cover the full range of prohibited activities (harm, harass, capture, kill, or take, and damage or destruction of residence), and includes reduction in production or productivity, as well as death of individuals.

MATERIALS AND METHODS

In accordance with the DFO evaluation framework, representatives of DFO Science, Fisheries Management, and Habitat Management, compiled a list of factors potentially resulting in mortality of Atlantic whitefish as a result of the following human activities:

Domestic Factors

- Directed fishing (with or without a quota) for a listed species
- Bycatch in fisheries directed at other species
- Detrimental impacts on habitats by fishing activities
- Direct mortality by permitted habitat alterations
- Detrimental alteration of habitats by permitted activities
- Ecotourism and recreation
- Shipping, transport and noise
- Fisheries on food supplies
- Aquaculture; Introductions and Transfers
- Scientific research
- Military activities

Non-Domestic Factors

- Long Range Transport of Air Pollutants

Data sources included:

1. information cited in the 2000 COSEWIC Species Status Report (Edge and Gilhen, 2001),
2. departmental records associated with industries and activities regulated by DFO, and
3. information arising from recent research activities and consultations.

Activities were described in terms of the mechanistic basis (cause and effect) through which harm could be induced, and whether an activity is of current concern or whether it may be a future concern as recovery actions are implemented to expand the geographic range of the species. Each activity was then assigned a relative rank effect (RRE, where 1 = highest known effect, 2 = moderate effect relative to highest known, 3 = low effect relative to highest known; NA = not applicable). Alternatives to the activity (e.g., relocation to areas not occupied by Atlantic whitefish) were assessed and measures that could be taken to mitigate the effect of the activity on Atlantic whitefish survival or recovery were defined.

RESULTS

DOMESTIC SOURCES OF HUMAN-INDUCED MORTALITY

Directed Fishing

Section 6 of the *Maritime Provinces Fishery Regulations* (MPFR's) specifically prohibits the retention or possession of Atlantic whitefish; there are no legal fisheries for the species. There are no known or anticipated illegal fishing activities directed at Atlantic whitefish. Directed fishing was therefore dismissed as a potential source of mortality (RRE =NA).

Bycatch in Fisheries Directed at Other Species

There are several known commercial and recreational fisheries that are managed under various regulations that could affect Atlantic whitefish, for example, white perch angling (Tables 1 and 2). In addition to *SARA*, at least five other pieces of federal legislation have direct or indirect application to Atlantic whitefish, namely, the *Fisheries Act*, the Fishery (General) Regulations (F(G)R's), the *Maritime Provinces Fishery Regulations* (MPFR's), the *Atlantic Fishery Regulations, 1985* (AFR's), and the *Aboriginal Communal Fishing Licences Regulations* (ACFLR's). The *Fisheries Act* is directed at protecting fish habitat while its supporting regulations provide the tools to protect, conserve and manage fisheries. Three of the most important regulatory provisions as applied to Atlantic whitefish are:

a) Section 6 of the MPFR's which prohibits the retention or possession of Atlantic whitefish,

b) Section 6 of the F(G)R's which provides for the issue of variation orders to close any fishing season set out in regulations, and

c) Section 22 of the F(G)R's which provides for the issue of licence conditions.

Fisheries of current concern and potential future concern are as follows:

<u>Recreational Angling Fisheries</u>

Susceptibility of the lake-resident population of Atlantic whitefish to incidental capture by anglers offering either artificial flies, or baited and unbaited lures is well documented (Edge and Gilhen 2001; Bradford et al. 2004). Bycatch had been a concern in the past primarily because of the potentially negative effects on survival which could occur from the handling of the fish during their release to the wild. Therefore, and after consultation with stakeholders, DFO and the Province of Nova Scotia agreed to additional management measures on the Petite Rivière to reduce the likelihood of incidental capture of Atlantic whitefish, effective in 2003. By variation order, all angling is now prohibited annually from April 1 to June 30 in the inland waters of Minamkeak, Milipsigate and Hebb lakes (Fig. 2), including the streams joining them. Commencing in 2005, only unbaited lures and artificial flies (no bait) will be permitted in these lakes and connecting waterbodies during the open angling season from July 1 to September 30.

Loss of anadromous runs on both the Tusket-Annis and Petite Rivière drainages effectively means that Atlantic whitefish are not currently susceptible to high incidental capture in marine recreational fisheries. However, captures of Atlantic whitefish by anglers below Hebbville Dam have been reported, the incidence of capture is low (Bradford et al. 2004). There are confirmed captures by anglers fishing rainbow smelt (*Osmerus mordax*) during the winter months on the LaHave River Estuary (Edge and Gilhen, 2001). The incidence of capture in this fishery is, as well, low (Bradford et al. 2004). Atlantic whitefish occurring below Hebbville Dam are thought to be members of the lake-resident population that have fallen over dam (Bradford et al. 2004). The lakes cannot be accessed from below due to an absence of fish passage facilities (Bradford et al. 2004). It is believed that these fish do not contribute to Atlantic whitefish production because they cannot return to the three lakes (Bradford et al. 2004).

Relative Rank Effect

The current RRE of bycatch in recreational fisheries is assessed as low (RRE =3). Measures (identified above) have already been enacted through existing regulations to reduce the likelihood of incidental capture in areas known to support Atlantic whitefish. There is no evidence of a bycatch of Atlantic whitefish in any recreational fishery occurring outside of Minamkeak, Milipsigate, and Hebb Lakes and their connecting waterbodies.

Human-induced mortality arising from bycatch in recreational fisheries will warrant consideration in the future as actions are implemented to expand the range of the species (Tables 1 and 2).

Mitigation

Additional changes to the regulation of the fisheries are possible on an as-required basis.

Commercial Fisheries

Bycatch of Atlantic whitefish in commercial traps or nets has been reported in the past (Edge and Gilhen 2001) and is of concern due to the potential for mortality to occur through entanglement, entrapment or handling. There are commercial fisheries in the Petite Rivière and estuary for gaspereau (a collective term for alewife (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*)) and American eel (*Anguilla rostrata*). Records indicate that Atlantic whitefish have been captured in the April-June gaspereau gillnet fishery as recently as 1997 (Edge and Gilhen 2001). The one remaining commercial gaspereau gill net licence holder in the estuary of the Petite Rivière was required in 2000, by a section 22 M(G)R's licence condition, to relocate his fishing gear to an area outside of the estuary in order to protect Atlantic whitefish.

One eel weir which targets downstream migrating silver eel is installed during late summer-autumn in the Petite Rivière approximately 1km below Fancy's Lake (Fig. 2). All fish are maintained live in a box until the weir is fished. Any Atlantic whitefish intercepted in the weir can be released live to the wild. There are no records of Atlantic whitefish having been captured in the weir. None have been observed in the catch by DFO conservation officers during routine inspections (Mr. Bob Barnes (retired), DFO Area Office, Bridgewater, personal communication).

There are confirmed historical reports of anadromous Atlantic whitefish captures in herring weirs located along the coast of southwestern Nova Scotia in 1919 (Edge and Gilhen 2001). These fish were presumably members of the now extirpated Tusket-Annis rivers (Fig. 3) population (Edge and Gilhen 2001). There are as well credible but unconfirmed reports of Atlantic whitefish captures in the March-June gaspereau gillnet fisheries in the estuary shared by the Tusket and Annis rivers during the 1940's and 1950's (Edge et al. 1991; Gilhen 1977; Edge and Gilhen 2001).

Relative Rank Effect

The current RRE of bycatch in commercial fisheries is assessed as low (RRE =3). They are conceivably susceptible to capture in only a single piece of gear (eel weir, Petite Rivière) and there are no records of the gear having captured an Atlantic whitefish.

Human-induced mortality arising from bycatch in commercial fisheries will warrant consideration in the future as actions are implemented to expand the range of the species, most notably through actions to encourage anadromy on the Petite Rivière, or to repatriate the species to the Tusket-Annis rivers (Tables 1 and 2).

Mitigation

Existing regulations can be applied to reduce bycatch of Atlantic whitefish in commercial fisheries on an as-required basis.

Detrimental Impacts on Habitats by Fishing Activities

Fishing gear installed in rivers and estuaries may impede fish passage or alter the substrate in a fashion that could negatively affect the supporting habitat. There are currently few concerns that harm will occur from the installation of fishing gear. The eel weir installed seasonally on the Petite Rivière is the only known piece of fishing gear which could conceivably impact Atlantic whitefish habitat. Operation of the weir is restricted by regulation to no more than 2/3 of the river channel and is not considered a barrier to upstream passage. Atlantic whitefish are virtually absent from the river drainage area lying below Hebbville Dam (Bradford et al. 2004). The weir site does not offer supporting habitat to Atlantic whitefish at present.

There has been significant alteration of fish habitat on the lower portions of the Tusket and Annis rivers to facilitate gaspereau dipnetting operations that occur every year during March-June. Through the preceding decades rocks on the stream bed have been re-arranged into low walls running parallel to the river bank as a means to create channels through which gaspereau are guided to the dipnet operator. Neither the extent to which these sites impede migration of Atlantic whitefish, nor the extent to which supporting habitat has been altered are known.

Relative Rank Effect

The current RRE of habitat alteration by fishing activities is assessed as low (RRE =3). The sole piece of gear (eel weir, Petite Rivière), installed in the only river known to support the species is not located in an area that offers supporting habitat.

The potential for habitat alteration resulting from fishing activities on the Tusket-Annis rivers will require assessment should measures to repatriate Atlantic whitefish to these rivers proceed. The effects of the eel weir on the Petite Rivière may require re-assessment once measures to promote Atlantic whitefish anadromy on this river proceed.

Mitigation

There are no indications that mitigation is required to reduce the impact of existing fishing activities on habitat. Enforcement of existing regulations is considered adequate.

Direct Mortality by Permitted Habitat Alterations

As directed by the DFO allowable harm evaluation framework, this category is to include activities that are either permitted by DFO, permitted by someone else who looks to DFO for advice, or are permitted by another authority on behalf of DFO. Note that the terminology used above is not consistent with that used by the DFO Habitat Management Program (HMP) in the administration of the habitat protection provisions of the *Fisheries Act*. HMP restricts use of the term “habitat alteration” to Section 35 of the *Fisheries Act* which prohibits the harmful alteration, disruption or destruction of fish habitat (HADD). “Habitat alteration” is used within the allowable harm framework to describe a broader set of activities that would not all be considered HADDs under the Fisheries Act. As well, DFO does not, strictly speaking, “permit” HADDs, rather they are authorized. The allowable harm framework also considers toxic chemical pollution to be “habitat alteration”. Chemical pollution is typically dealt with under Section 36 of the *Fisheries Act* which does not mention the term “habitat alteration”. This assessment considered the following activities:

<u>Hydroelectric Generating Facilities</u>

Historically, hydroelectricity was generated on both the Tusket (1929-present) and Petite (1939-1971) rivers. In both instances dams were constructed to create head to power turbines, to store water and to manage flows. Factors likely to result in direct mortality may have included the killing or injury of fish passing through turbines (blade strike, cavitation), and reservoir drawdown during the winter months, potentially exposing eggs or larvae to the atmosphere, as is known to occur within reservoir-resident coregonid populations (Machniak 1975; Tikkanen et al. 1988; Winfield et al. 1998; Jansen, 2000).

Hydroelectric generation practices have been cited as a factor contributing to the extirpation of the anadromous Tusket River population (Edge and Gilhen 2001). Their role as a contributing factor to the collapse of a suspected anadromous run on the Petite Rivière is not known. There are no indications within DFO records that Atlantic whitefish fish passage and habitat requirements were a consideration in the regulation of the hydroelectric industries on either the Tusket (Appendices I and II) or Petite (Appendix III) rivers.

Although the specific cause and effect of the Tusket River facilities on Atlantic whitefish survival were not assessed (Bradford et al. 2004), it may be significant that 1) the indications of a pronounced decline in abundance were not evident until the 1950's (Edge and Gilhen 2001); and, 2) Atlantic whitefish persisted on the river at least until 1982 (Bradford et al. 2004). These dates are significant in the context of allowable human-induced harm (as it relates to future actions to repatriate Atlantic whitefish to the Tusket River) because they suggest the physical presence alone of a hydroelectric generating facility on that river since 1929 was not likely the sole factor responsible for extirpation of the species. Future mitigation may therefore be possible. The chronological records contained in DFO files concerning changes with time in hydroelectric generation practices and provision of fish passage are presented in Appendix I for upstream passage and Appendix II for downstream passage.

Relative Rank Effect

Atlantic whitefish are no longer present on the Tusket River. Generation of hydroelectricity no longer occurs on the Petite Rivière. The current RRE of hydroelectric generation facilities is therefore assessed as not applicable (NA).

Hydroelectric generating facilities will require future assessment as a contributor to direct Atlantic whitefish mortality should efforts to repatriate the species to the Tusket River proceed.

Municipal Water Extraction

Municipal water extraction can cause mortality or injury if fish are taken into the water intake pipes.

The Town of Bridgewater extracts water from Hebb Lake for municipal use through two 0.3m in diameter and 0.9m in length screened intakes (slotted screen having a 6mm slot size). The Town is currently licensed to extract 6,800 m^3/day up to a maximum of 15,500 m^3/day. Corresponding withdrawal rates vary between 260 - 460 m^3/hour. Maximum and average entrance velocities at the intake are therefore:

	$260m^3/h$	$460m^3/h$
Maximum (m/s)	0.058	0.103
Average (m/s)	0.042	0.074

Withdrawal rates vary depending on time of year, being greatest during mid to late summer and lowest from approximately late December to mid January. Water extraction occurs continuously: 24 hours a day, seven days a week, with few sudden changes in flow (Tim Hiltz, Town of Bridgewater Public Service Commission, personal communication).

The Town is in the process of renewing its withdrawal approval under the "Guide to Surface Water Withdrawal Approvals" issued by the Nova Scotia Department of Environment and Labour (May 7, 2004). The proposed 20 year plan envisages a maximum withdrawal of 760 m^3/h; the corresponding maximum and average entrance velocities at the intake are 0.17m/sec and 0.12m/sec respectively.

There are no water extraction operations for municipal purposes on the Tusket River.

Relative Rank Effect

The current relative rank effect of municipal water extraction on Atlantic whitefish is assessed low (RRE =3). Designated water area regulations for Hebb and Milipsigate Lakes were approved in 1964, and those for Minamkeak in 1975 (Llewellyn et al. 2000), indicating that the lakes have been managed as the municipal water supply for the Town of Bridgewater since at least the mid-1960s. The continued presence of a resident population of Atlantic whitefish within the lakes indicates that the recent and current water extraction practices and rates have not threatened survival of the species.

The RRE of municipal water extraction on Atlantic whitefish may change in the future in association with the anticipated increase in water extraction rate. Mitigation to minimize mortality, if demonstrated to be necessary, may include improved screening on the intake pipes or regulation of withdrawal velocities.

Municipal Water Drawdown

Reservoir drawdown within municipal water supplies could potentially result in direct mortality on Atlantic whitefish if habitat harbouring eggs and larvae is dewatered. The daily volume of water withdrawn from the Petite Rivière system to meet municipal needs does not alter lake levels; i.e., they fluctuate with seasonal conditions (Tim Hiltz, Town of Bridgewater Public Service Commission, personal communication). There are no requirements with regard to drawdown within the current withdrawal approval (Tim Hiltz, Town of Bridgewater Public Service Commission, personal communication). Records of seasonal variability in lake (reservoir) levels are available from the Town of Bridgewater Public Service Commission.

Relative Rank Effect

The RRE of municipal water drawdown on Atlantic whitefish survival is assessed low (RRE =3). There are no indications that current drawdown practices, or in the recent past, have threatened survival of lake resident Atlantic whitefish.

The RRE may change in the future should information related to Atlantic whitefish habitat spawning preferences become available. The records of lake levels during the spawning and incubation periods could then be used to current assess scope for harm to either eggs or larvae. Similarly, the potential for future harm arising from the proposed increased volume and rate of extraction to meet the anticipated increased municipal water requirements should be assessed.

Mitigation

Historical records of the seasonal variability of water levels within Minamkeak, Milipsigate, and Hebb lakes are available to establish drawdown benchmarks to protect Atlantic whitefish eggs and fry, once spawning site preferences and characteristics are identified.

Detrimental Alteration of Habitats by Permitted Activities

As directed by the DFO allowable harm evaluation framework, these activities are either permitted by DFO, are permitted by someone else who looks to DFO for advice, or are permitted by another authority on behalf of DFO; and, could occur as a result of presence of foreign materials, forces or noises that may detrimentally alter Atlantic whitefish habitat through loss of aquatic productivity. Note that the terminology used above is not consistent with that used by the DFO Habitat Management Program (HMP) in the administration of the habitat protection provisions of the *Fisheries Act*. HMP restricts use of the term "habitat alteration" to Section 35 of *the Fisheries Act* which prohibits the harmful alteration, disruption or destruction of fish habitat. "Habitat alteration" is used within the allowable harm framework to describe a broader set of activities that would not all be considered HADDs under the Fisheries Act. As well, DFO does not, strictly speaking, "permit" HADDs, rather they are authorized. The allowable harm framework also considers toxic chemical pollution to be "habitat alteration". Chemical pollution is typically dealt with under Section 36 of the *Fisheries Act* which does not mention the term "habitat alteration". This assessment considered the following activities:

<u>Hydroelectric Generating Facilities</u>

Generation of hydroelectricity has occurred on the Tusket River since 1929 (Edge and Gilhen 2001) and occurred on the Petite Rivière from 1939-1971 (Appendix III). Hydroelectric generating operations were identified as a factor contributing to the loss of the anadromous Tusket-Annis population (Edge and Gilhen 2001) but their impact on a suspected historical anadromous run on the Petite Rivière (Edge and Gilhen 2001) is not known. While no operations currently threaten the survival or recovery of Atlantic whitefish, they require consideration in the context of allowable harm because repatriation of Atlantic whitefish to the Tusket River, part of their known former area of occupancy, is a stated goal of the Recovery Strategy. As well, and even though hydroelectricity is no longer generated on the Petite Rivière, many of the alterations to habitat in the river that were made to manage water flows still exist. For example, several of the storage dams used by the Town of Bridgewater to manage water for municipal use were originally constructed to facilitate the generation of hydroelectricity. The chronology of hydroelectric generation on this river is presented in Appendix III and summarized where appropriate in this section of the document in order to provide context to contemporary Atlantic whitefish habitat issues.

The habitat requirements for Atlantic whitefish are known in only general terms (Bradford et al. 2004). Habitat alterations arising from the hydroelectric generating operations that could potentially contribute indirectly to Atlantic whitefish mortality can only be assessed through application of equivalent information acquired from assessment of related species. Negative effects cited for other coregonid fishes include 1) reductions in opportunities to spawn (inadequate or inefficient fish passage around dams, dewatering of habitat), 2) reduced forage base within reservoirs leading to reduced fish production, and 3) increased year-class variability. These factors, acting either individually or in combination, can reduce absolute coregonid abundance (Machniak 1975; Tikkanen et al. 1988; Winfield et al. 1998; Jansen 2000).

Tusket River

The chronology of changes to fish passage facilities and flow requirements on the Tusket River are well documented in DFO internal documents (Appendices I and II) and indicate that indirect mortality may have affected the declining status of the anadromous run on the river. Fishways have been in some manner of operation since 1929 at both the Powerhouse and Vaughn dams. Concerns with the adequacy of both upstream (Appendix I) and downstream (Appendix II) fish passage around the dams and turbines were expressed shortly after hydroelectric operations commenced.

Bypass facilities and corresponding maintenance flows have changed over the years since 1929 in efforts to improve passage (Appendices I and II), for either Atlantic salmon or gaspereau. Requirements for Atlantic whitefish were not explicity addressed. The present flows through the upstream and downstream bypass facilities installed in the dams on the Tusket River have been established mostly through regulation (Table 3) while others reflect a best-effort on the part of Nova Scotia Power Inc. (NSPI; Table 3). DFO records of possible significance (Appendix 1) to upstream passage of anadromous Atlantic whitefish in the Tusket River may include:

1. January 1930 - April 1931: the Powerhouse fishway was in place but not functioning effectively as fish (salmon and gaspereau) ascended only 2/3 of the way up.
2. Provision of effective upstream passage questioned on numerous occasions at both dams throughout the ensuing decades (Appendix I), however, Atlantic whitefish were reported above the top of the Powerhouse Dam fishway as late as 1976 (Gilhen 1977).
3. Dewatering of fishways for the winter months appears to have been a common practice. The power company was requested on September 29, 1978, to consider maintaining a flow of water through the Powerhouse fishway after November 15.

Issues of possible significance (Appendix II) to the downstream passage of Atlantic whitefish may include:

1. Other than descent through the top of the fishway, no specific provisions for downstream bypass of fish of any species were provided from the date of first operation until spring 1973 (see #4 below).
2. 1940 onward: Throughout the years, accounts of inadequate water flow, algal buildup, and the presence of fish (counting) traps in the fishway indicate that the fishways may not have been suitable as downstream bypass facilities.
3. 1948 – 1973: Various accounts of high levels of gaspereau mortality during downstream migrations. Fish were either being forced to pass through the turbines, or became trapped and died against the screens installed to prevent entrainment of fish through the turbine bays.
4. June 13, 1958. It is proposed that one (the so-called ‘4th bay’) of four turbine bays located in the Powerhouse Dam be operated as a downstream bypass facility. The bay became operational as a downstream bypass facility in spring, 1973. The 4th bay continues to be operated as a downstream bypass facility.

Since 2000, NSPI has adopted, as a precautionary conservation measure, the practice of maintaining a flow through the Vaughn fishway until after December 31. This date corresponds approximately with the time at which most of the captive Atlantic whitefish on site at the Mersey Biodiversity Facility have ceased spawning. Therefore, and even though there are no indications that Atlantic whitefish are still present in the Tusket River, there is opportunity for any remaining members to access the reservoirs for spawning for the duration of the spawning season. It can be noted as well that a fishway is scheduled to be constructed around a dam located at Gardner's Mills, on the Annis River, that for several decades has denied anadromous fishes access to the upper 50% of the river drainage.

Drawdown in storage reservoirs associated with hydroelectric generation on the Tusket can occur either for maintenance of the dams and associated structures, or to release water to generate power. Drawdowns associated with maintenance work are subject to approval by the Nova Scotia Department of Environment and Labour.

Petite Rivière

The history of dam construction on the Petite Rivière and its lakes extends back to the 1700's. Constructed initially to power mills, by 1939, several of the dams had assumed a role in managing water flows for hydroelectric generation (Appendix III)[1]. The dam situated on the main stem of the Petite Rivière at Conquerall Mills (Fig. 2) appears to have been the only structure constructed explicitly for the purpose of hydroelectric generation. Powerhouses were located at Conquerall Mills and Hebbville Dam (Fig. 2). Hydroelectric operations ceased at both sites in 1971 (Appendix III). Dams constructed at the outlets of Minamkeak and Milipsigate lakes managed flows to the turbines located in the Hebbville dams situated at the base of Hebb Lake (Fig. 2). The Conquerall Mills Dam was breached in 1977, the Hebbville Dam remains in place.

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[1] A wooden dam was constructed during 1889 on the main stem of the Petite Rivière at Crousetown (Fig. 2) to provide water power to a mill. This site was never used to generate hydroelectricity and although the dam no longer has an industrial use the structure was repaired in 1945 and is still in place. A run-around channel (fishway) constructed of loose native stone has been in place since the construction of the dam. Repairs to the fishway have occurred throughout the years (Appendix III) and the fishway is known to provide upstream access to anadromous gaspereau and Atlantic salmon. Maintenance flow through the runaround channel is provided by private interests on a best effort basis by manipulation of the wooden orifice at the top of the dam. There is no certainty that flow through the channel is, or ever was, managed after the Atlantic salmon autumn migration has ceased (~mid-November). It may be noteworthy that wild-caught lake resident Atlantic whitefish have consistently spawned between late December and mid-January in captivity at the DFO Mersey Biodiversity Facility (John Whitelaw, unpublished data). The Crousetown Dam may therefore present a barrier to upstream fish passage at the time when anadromous Atlantic whitefish would be ascending the Petite Rivière to spawn. There are no apparent downstream fish passage concerns at the Crousetown Dam as passage is provided by spillage over the lip of the dam.

The Conquerall Mills Dam and the Crousetown Dam were the only man-made barriers on the Petite Rivière for which there were specific requirements, under the *Fisheries Act*, for provision of fish passage. A request to provide inter-lake passage for Atlantic salmon and gaspereau between Minamkeak, Milipsigate, and Hebb lakes, as well as an upstream bypass for these species around the structures at the base of Hebb Lake, was received by federal fish passage engineers in 1979 (Appendix III). This request was not approved as internal resource development priorities at the time required that fish passage result in economic gain. Only downstream passage has been possible at these sites via spillage through flow control structures (Appendix III).

Conquerall Mills

Turbines, installed in 1939, at Conquerall Mills received water from a penstock constructed to the side of the river channel. A fishway, apparently installed at the time of dam construction, was designed to use waters from the tailrace of the hydroelectric plant as attraction water. DFO records do not include local or DFO concerns with fish passage at this site; this may indicate that fishway operations were relatively efficient (Appendix III). There are no early records specifically pertaining to downstream passage at Conquerall Mills. Alternate routes to passage through the turbines may have included the entrance to the top of the fishway, and a sluice which spilled water directly into the original river channel.

DFO records (Appendix III) indicate that when hydroelectric generation activities ceased in 1971, upstream migrant fish (i.e., Atlantic salmon, gaspereau) were no longer attracted to the fishway owing to a lack of attraction water. Maintenance of adequate flows to the fishway became more difficult. The trapping and trucking of fish over the dam was required occasionally. The Conquerall Mills dam was breached in 1977 (Edge and Gilhen 2001). However, the current ability for fish to migrate upstream unimpeded at this location is unknown. There is concern that a velocity barrier may exist at the site during periods of freshet owing to the hydrology of water flow through the breached section of the dam (Vern Conrad (retired), DFO fish passage engineer, personal communication).

Hebbville Dam and Upper Lakes

The hydroelectric generating facility, which operated between 1939 and 1971, received water from a penstock blasted through the lake shore approximately 1km to the west of the natural river channel. There are no records to indicate that fish passage, either upstream or downstream, was provided. The penstock and dam are still in place. Leakage occurring through the dam drains into Fancy’s Lake (Fig. 2). However, the bulk of the water exiting Hebb Lake is managed through the main (Hebbville) dam built across the river channel.

Although there were no regulatory requirements to provide upstream fish passage around Hebbville Dam there are credible reports of gaspereau and Atlantic salmon occurring upstream of the dam prior to an upgrade of the dyke and dam around 1970 (P. Longue, Laconia, N.S. personal observation). These reports complement assertions by local residents, now confirmed by the Town of Bridgewater Public Service Commission, that seasonal access to Hebb Lake was possible for upstream migrating fish through a sluiceway prior to the dyke and dam upgrades (Mike Fox, Town of Bridgewater Public Service Commission, personal communication). There is no record of the existence of this sluiceway in fish passage files maintained by DFO.

Minamkeak Lake, at the top of the system, was diverted from the Medway River into the Petite Rivière in 1939, presumably to provide additional water for the generation of hydroelectricity. Storage dams were constructed at outlets of both Minamkeak and Milipsigate lakes at approximately the same time; these are still in place.

Relative Rank Effect

Hydroelectric generation has long ceased on the Petite Rivière. Atlantic whitefish are no longer present on the Tusket River. The current RRE associated with operations is therefore assessed not applicable (Rank =NA). However, the physical legacy of the industry on the Petite Rivière remains in the form of known and suspected barriers to fish passage. The dam located at the base of Hebb Lake, and a potential velocity barrier at the decommissioned dam site at Conquerall Mills, may be contributing factors to the current low abundance of anadromous Atlantic whitefish on this river. These considerations indicate that, from a different perspective, the current RRE could be high (RRE =1) owing to lingering fish passage issues.

Adequacy of fish passage and reservoir water level management will both be future considerations on the Tusket River should plans to repatriate Atlantic whitefish to the river proceed.

Mitigation

There is likelihood that Atlantic whitefish could benefit from improvements to fish passage on the Petite Rivière, namely through improved regulation of flow through the Crousetown fishway, elimination of any velocity barrier at the decommissioned Conquerall Mills damsite, and through provisions for upstream and downstream fish passage at the Hebbville Dam. The potential benefits to Atlantic whitefish survival through improved access among Minamkeak, Milipsigate, and Hebb lakes warrants consideration.

Municipal Water Storage and Drawdown

Water management, including storage and drawdown to meet the municipal needs of the Town of Bridgewater, could potentially contribute indirectly to Atlantic whitefish mortality either by impeding normal migratory behaviour as a result of inadequate fish passage, or through reduction in the productivity of aquatic habitat as a result of water level fluctuations. The current and anticipated water requirements for the Town are described above under 'Direct Mortality by Permitted Habitat Alterations'.

The Town currently regulates flow through barriers located at the outlets of Minamkeak, Milipsigate and Hebb lakes. The barrier potentially having the most pronounced indirect negative effect on Atlantic whitefish is the Hebbville Dam. Absence of an upstream fish passage facility at this site negates any opportunity for Atlantic whitefish that have fallen over the dam to return to the lakes and thus represent an absolute loss of production within the lake resident population. The effects on Atlantic whitefish production of impediments to free movements of the species among the three lakes are not known.

There are no indications that manipulations within the reservoirs to meet the water requirements of the municipality indirectly threaten the survival of lake-resident Atlantic whitefish. The volume of water extracted does not substantively alter lake levels; i.e., they fluctuate with seasonal conditions (Tim Hiltz, Town of Bridgewater Public Service Commission, personal communication). However, there are no requirements with regard to drawdown within the current withdrawal approval (Tim Hiltz, Town of Bridgewater Public Service Commission, personal communication). Records of seasonal variability in lake (reservoir) levels are available from the Town of Bridgewater Public Service Commission.

There are no water extraction operations for municipal purposes on the Tusket River.

Relative Rank Effect

The RRE of current municipal water drawdown on the detrimental alteration of Atlantic whitefish habitat is deemed to be low (RRE =3). The species has persisted in the lakes in an absence of specific provisions to protect supporting habitat. Absence of upstream fish passage facilities at the Hebbville Dam contributes indirectly to Atlantic whitefish losses by effectively preventing fish that have fallen below the dam from contributing to the parent population. The RRE of the Hebbville dam is assessed high (RRE =1).

Mitigation

Impediments to the free movement of Atlantic whitefish either among the lakes or between the lakes and the river and estuary could be mitigated through the provision of adequate upstream and downstream fish passage facilities. Minimum drawdown provisions to protect supporting habitat within the lakes should be specified if shown to be necessary to protect against the effects of either current or proposed future drawdown volumes.

Urbanization

Urbanization typically involves activities that both alter shorelines (e.g., artificial beaches, docks, retaining walls, boat ramps), which may reduce production and forage base, and increased domestic waste leachate. These activities can detrimentally alter fish habitat.

All Canadian fisheries waters receive general protection from the Fish Habitat provisions of the *Fisheries Act*. These provisions prohibit the harmful alteration, disruption or destruction (HADD) of fish habitat without authorization by the Minister (Section 35 administered by the DFO Habitat Management Program), and prohibit the deposit of deleterious substances into waters frequented by fish (Section 36 administered by Environment Canada). Note that HADD Authorizations are project specific in nature and generally unable to effectively consider cumulative environmental effects. HADD Authorizations do not consider land use, nor are they meant to be a land-use, urban planning tool.

In lakes and rivers, the Nova Scotia Department of Environment and Labour issues permits for building wharves or any other structures below the ordinary high water mark (OHWM). Structures that do not fall within the standard guidelines may be reviewed by other government departments, including DFO (for compliance with Fisheries Act), and may undergo an environmental assessment.

The lakes supporting a resident Atlantic whitefish population within the Petite Rivière provide water for municipal use to the Town of Bridgewater and water quality within the lakes is monitored regularly by the Public Service Commission. The Nova Scotia Environment Act (1994-1995), which replaced the Waters Act, is the provincial legislation in place to protect lakes and watersheds for municipal water use. Those watersheds that were protected under the old Waters Act, including those on the Petite, were not automatically protected under the new Act. Old regulations for Hebb, Milipsigate and Minamkeak Lakes are no longer applicable or enforceable. NSDEL is currently developing a Watershed Protection and Management Plan for Hebb, Milipsigate and Minamkeak Lakes with the Town of Bridgewater and a watershed management committee of stakeholders. A set of regulations under section 106 of the Environment Act will accompany this plan, and will replace the former regulations provided under the Waters Act. Once the management plan and regulations are in place, the Town of Bridgewater will be responsible for enforcing the legislation. NSDEL estimates that the Management Plan will be in place by fall 2005. Although no enforceable regulations are currently in place to protect the drinking water quality of the watershed, NSDEL feels that there is general public acceptance that these lakes are protected; they do not anticipate problems within the next 6 months before the new regulations take effect (Graham Fisher, NSDEL, pers. comm.).

The past general prohibitions against deterioration of water quality by human activities in Hebb and Milipsigate lakes was not aimed at protecting the endangered Atlantic whitefish, however it is assumed that protecting water quality can only be beneficial to the species. Hebb and Minamkeak lakes were identified in **THE ROYAL GAZETTE**, Wednesday, June 17th, 1964, under the authority of the Nova Scotia Waters Act. The restrictions or prohibitions regarding activities around/on these two lakes identified by Mr. H.A. March, Secretary Treasurer for the Bridgewater Public Service Commission, are as follows:

"No person shall, (a) place, deposit, discharge or allow to remain therein any material of kind that may impair the quality of the water; or (b) bathe, wash, or otherwise impair the quality of the water."

Regulations were put in place to protect water quality in Minamkeak Lake on April 22, 1981. These extensive regulations covered issues including erosion, deleterious substances, waste disposal, sewage disposal, pest control products, washing with detergents, and others. People were required to notify the Nova Scotia Department of Environment and Labour (NSDEL) and/or the Bridgewater Public Service Commission (BPSC) when planning to undertake any mining or forestry operations or construction activities, among others (Kendall and Llewellyn 2001). Llewellyn and others (2000) report that that notification about development within the watershed was rarely provided to the BPSC.

The river and lacustrine shoreline and waters below the Hebbville Dam are not within the boundaries of a protected watershed. These areas receive no added protection from the impacts of activities commonly associated with urbanization beyond that afforded to fish habitat by the federal *Fisheries Act* on a project by project basis. The shoreline of Fancy Lake has been extensively altered by private homeowners and summer recreational property owners. Many of the other lakes lying below Hebbville Dam are surrounded by privately owned lands which have been extensively, or increasingly so, developed as private homes or seasonal recreational properties. The Tusket and Annis rivers are experiencing similar development.

Relative Rank Effect

The current RRE of urbanization on Atlantic whitefish habitat is assessed low (RRE =3) although re-assessment will be necessary, in light of the extensive development of the lakes below Hebbville Dam, should efforts to encourage anadromy within the Petite Rivière population proceed. Urbanization will be a future consideration on the Tusket and Annis rivers should plans to repatriate Atlantic whitefish to these rivers proceed.

Mitigation

Watershed management can be strengthened through restrictions on permitted operations in areas known to offer supporting habitat to Atlantic whitefish. Best management practices on the part of private land owners can be encouraged through communication.

Irrigation

Irrigation has the potential to reduce river discharge which can lead to possible loss of fish habitat and as well could result in the dislocation of fish into irrigated fields from which there is no escape. Water extraction currently occurs on the Petite Rivière, immediately below Hebbville Dam, to irrigate a commercial cranberry growing operation. The intake is screened, extractions are seasonal, and are not thought to substantively reduce river discharge.

The extent of water extraction for the purpose of irrigation on the Tusket and Annis rivers is not known.

Relative Rank Effect

The relative rank effect of irrigation on the detrimental alteration of Atlantic whitefish habitat is deemed to be low (RRE =3). There are no indications the volumes extracted reduces river flow to an extent that reduces aquatic productivity; there are no indications that Atlantic whitefish are entrained (and thus trapped) in the cranberry bog.

Mitigation

Improved screening can be applied if shown to be warranted. Best management practices by the permit holders could include reducing extraction volumes at times when Atlantic whitefish are known to occur in the area of the intakes.

<u>Existing Mines and Quarries</u>

There are many abandoned gold mines and slate quarries in the catchment basin of the three lakes on the Petite Rivière that currently support Atlantic whitefish. These mines were abandoned over 50 years ago, and many of the sites are no longer owned by the mine/quarry operators.

At many of the abandoned mine sites waste rock and tailing piles remain, and the underground workings at the sites are now water filled holes (Llewellyn et al. 2000). Acid mine drainage is of some concern at these sites given that the bedrock composition of the watershed is high in acid producing metals. The present movement of water through the watershed system does not, however, appear to threaten the water supply area. Changes to the system, such as dewatering of the shafts, which could mobilize contaminants within the system, could present a threat. Water analysis of abandoned mine shafts (at depth) was recommended in a 2000 report to the Bridgewater Public Service Commission (Llewellyn et al. 2000). Run-off from the quarries is thought to have a largely localized effect on habitat. The Petite Rivière catchment is moderately and naturally well-buffered from acidification (see Long Range Transport of Air Pollutants below).

Current land-owners are not legally responsible to remediate the mining sites abandoned by past mineral claim owners; they are not required to mitigate run-off from these sites, including acid-run off resulting from the exposure of pyretic slate. The federal *Fisheries Act* applies only after contamination has occurred; however, if sites are orphaned, charges cannot be laid. NSDNR has a Minerals Policy (1996) which provides some impetus, but no requirement, to mitigate potential environmental damage by abandoned sites:

> …The Department is aware of the social, economic and environmental impacts of abandoned mine sites and will work with industry, and other departments and levels of government to identify ways and means for reclaiming abandoned mine sites.
>
> Specifically the Department will:
>
> - explore funding mechanisms to reclaim old mine sites, concentrating on those that pose the greatest risk to environmental health and human safety;
> - provide information and technical assistance to responsible parties for the clean-up and safety of abandoned sites;
> - encourage industry to explore, develop and eventually reclaim old mine sites.

The full suite of abandoned mines and quarries in the Tusket and Annis drainage basins has not been compiled. Unmitigated run-off from these sites may warrant assessment should plans to repatriate Atlantic whitefish to these rivers proceed.

Relative Rank Effect

The current RRE of abandoned mining and quarry operations on the detrimental alteration of Atlantic whitefish habitat is assessed moderate (RRE =2). Detrimental effects are likely localized within the streams draining into either Minamkeak, Milipsigate, or Hebb lakes, there are no indications that the cumulative run-off from these sites has reduced water quality within the lakes themselves to the extent that threatens the survival of Atlantic whitefish.

Mitigation

To minimize the effects of mining and quarries on fish habitat, best management practices could be put into place and which are designed to limit the environmental impact of the site.

Forestry

Forestry operations occur throughout the Petite Rivière and Tusket-Annis drainages. Lunenburg County (1980 cited by Llewellyn et al. 2000) identified forestry as a major potential threat to freshwater resources. Forestry activities can impact riparian habitat leading to loss of shoreline habitat and increased siltation of fish habitat.

DFO reviews infrastructure developments required to undertake forestry activities (e.g. roads, culverts, bridges) for compliance with the *Fisheries Act*, and responds to violations of the *Fisheries Act* caused by the forestry activity itself.

Clear cutting activity in the Minamkeak Lake watershed has occurred in recent years. Sayah (1999 cited by Llewellyn et al. 2000) noted an overlapping of cleared areas and waterbodies within the Petite Rivière watershed. Kendall and Llewellyn (2001) reported one instance where forest was cleared to the lake edge and machinery was driven through the outlet stream of Caribou Lake, a small lake that lies between Milipsigate and Minamkeak Lakes.

The new Wildlife Habitat and Watercourses Protection Regulations (2002) of the Forests Act, as well as previous statutes of that Act, require that a 20 meter buffer zone be maintained along watercourse boundaries when cutting. Poor cutting practices around waterbodies may also lead to contraventions of the habitat provisions of the federal Fisheries Act. This reported instance of cutting may not be typical of forestry activities within the watershed, however, it appears that current forest activities may not always be conducted in compliance with existing regulations. Efforts to manage activities within the watershed, such as forestry, may also be incorporated into future regulations being developed for the Petite Rivière Lakes under Section 106 of the Nova

Scotia Environment Act which designates and protects watersheds surrounding water supply areas.

Relative Rank Effect

The RRE of forestry on the detrimental alteration of Atlantic whitefish habitat is assessed low (RRE =3). There are no indications that current operations are not in compliance with existing regulations.

Mitigation

To minimize the effects of forestry on fish habitat, best management practices could be put into place. These may be incorporated into management plans or regulations under the Protected Water Area Designation of the NS Environment Act– currently being developed by BPSC and NSDEL.

Agriculture Run-Off

There are hay fields and pasture lands located to the north in the upper reaches of the Petite Rivière watershed. Agricultural activities can lead to land wash which could result in the eutrophication and siltation of fish habitat. There are no indications that agriculture currently poses a threat to water quality in the Petite Rivière (Llewellyn et al. 2000). The extent of agricultural operations in the Tusket and Annis rivers catchments has not been determined.

The *Fisheries Act* (sections 35 and/or 36) would apply to agriculture activities resulting in run-off after the resulting contamination or fish kills have occurred; however, the source of the run-off would have to be proven in order to lay a charge.

Relative rank Effect

The RRE effect of agriculture on the detrimental alteration of Atlantic whitefish habitat is assessed low (RRE =3) in light of the absence of indications that water quality is adversely affected.

Mitigation

To minimize the effects of agriculture on fish habitat, best management practices could be put into place

Ecotourism and Recreation

There are no known activities associated with the Ecotourism and Recreation industries that would adversely affect Atlantic whitefish habitat. The current RRE is accordingly assessed Not Applicable (RRE =NA).

Shipping and Transport and Noise

There are no known shipping or transport activities (and therefore associated noise) occurring within the Petite Rivière drainage that would adversely affect Atlantic whitefish habitat. The current RRE is accordingly assessed Not Applicable (RRE =NA).

Note that only aquatic shipping and transport were considered in this section. An analysis of land shipping and transport (i.e. highway and road development, ditched, bridges, salt) should be undertaken in the future.

Fisheries on Food Supplies

There are currently no fisheries operating within the Petite Rivière that could reduce the food supply for Atlantic whitefish. The current RRE is accordingly assessed Not Applicable (RRE =NA). Fisheries in the Tusket-Annis rivers area may require future assessment should plans to repatriate Atlantic whitefish to these rivers proceed.

Aquaculture; Introductions & Transfers

The National Code on Introductions and Transfers (NCIT) applies to all planned, legal releases of aquatic species into the wild or their transfer among water bodies. A licence authorizing the movements is required under Section 56 of the Fisheries General Regulations which states: The Minister may issue a license if

(*a*) the release or transfer of the fish would be in keeping with the proper management and control of fisheries;

(b) the fish do not have any disease or disease agent that may be harmful to the protection and conservation of fish; and

(c) the release or transfer of the fish will not have an adverse effect on the stock size of fish or the genetic characteristics of fish or fish stocks.

No introductions or transfers of aquatic organisms into the habitat within the Petite Rivière that currently or historically supports Atlantic whitefish has been proposed. It is unlikely that future introductions or transfers would be approved unless shown unequivocally not to result in Atlantic whitefish mortality. Assessment of legal introductions and transfers do not require consideration for allowable harm (RRE =NA).

However, recent appearances of certain (non-native) invasive fish species in each of the Tusket, Annis, and Petite rivers has elevated concerns regarding both the current and future status of Atlantic whitefish. Their presence is not the result of any planned, legal introductions and are therefore not a consideration under a theme of 'Aquaculture: Introductions and Transfers'. Regardless some statement of risk of harm to Atlantic whitefish is warranted in light of the likelihood that, once introduced into a river drainage, the species will colonize new areas, possibly including the entire known current area of occupancy of Atlantic whitefish.

Invasive Species

Smallmouth bass (*Micropterus dolomieu*) and chain pickerel (*Esox niger*) were introduced to single Nova Scotia lakes in 1908 (NSDAF 2004) and 1944 (Jason LeBlance, NSDAF, Pictou, personal communication) respectively. Both species have since become established in numerous river drainages through a combination of planned and illegal transfers.

Chain pickerel, first reported present in the Annis River (Fig. 3) in 1976, are now widespread throughout the drainage (Bradford, et al. 2004). There are reports of their presence in Lake Vaughn, Tusket River (R.G. Bradford, personal observation). Chain pickerel are not known to occur in the Petite Rivière drainage.

The full suite of pathways contributing to negative interaction between chain pickerel and native Nova Scotia fishes is unknown. Their presence in lakes within the Annis River, however, has been concurrent with the decimation of both warm- and cool-water tolerant soft-rayed fish species, including lake whitefish (Bradford et al. 2004). An illegal introduction of chain pickerel into the Petite Rivière lakes above Hebbville Dam could have a similar, profound negative consequence for Atlantic whitefish survival. It is not currently possible to determine the likelihood of Atlantic whitefish and chain pickerel coexistence in the Tusket-Annis should efforts be made to repatriate Atlantic whitefish to these rivers. The freshwater residency time for various life-history stages of anadromous Atlantic whitefish is unknown.

Smallmouth bass, first reported in the Carleton River (Fig. 3) in 1989, are now widespread throughout the drainage, including the Tusket branch. Their presence in the Petite Rivière drainage was first noted in 1994 in Wallace Lake, which drains to the river below Hebbville Dam (Fig. 2). There are now established populations in many of the other lower lakes either through colonization or further illegal transfers. Smallmouth bass were first reported present above Hebbville Dam in 2000, and confirmed with captures from Andrew Lake (Fig. 2). Monitoring activities by the Atlantic Whitefish Conservation and Recovery Team since the discovery of these fish above the dam has revealed the following:

- 2000-2001 smallmouth bass successfully reproduce in Andrew Lake
- 2001 smallmouth bass detected in both Minamkeak and Hebb lakes
- 2003 Habitat Stewardship Program (HSP) survey (angling, visual) confirmed smallmouth bass life-cycle closure within Minamkeak Lake, no indication of successful reproduction in either Milipsigate or Hebb Lake
- 2004 presence re-affirmed in Minamkeak Lake, presence not detected in Milipsigate Lake (angling, visual surveys).

The effects of invasive smallmouth bass on Ontario lakes' native fish assemblages have been studied in detail. The most pronounced effects occur though predation, habitat displacement, and trophic disruption (Jackson, 2002).

Direct predation on young Atlantic whitefish cannot be completely discounted in light of observed presence of age 0+ Atlantic whitefish in the littoral zone during early summer (Hasselman et al. submitted). Trophic disruption is plausible, and may pose a threat to survival. Briefly, and as described in Vander Zanden et al. (1999, 2004), the degree of interaction between cool water invasive and cool water native species depends upon trophic structuring within a specific lake. Negative interaction is possible when cool water species acquire energy from consumption of littoral fishes ('minnows'). After their introduction, young smallmouth bass replace the native littoral fish community; it is not always the case that young smallmouth bass are usable as forage by the cool water species. The presence of a pelagic forage base (e.g., smelts, lake herrings), however, has an insular effect on native cool water species that are to some degree piscivorous.

Edge (1984) demonstrated that land-locked Atlantic whitefish are piscivorous; the lakes presently supporting Atlantic whitefish do not possess pelagic forage species. Depression of littoral fish abundance and diversity in Minamkeak Lake is evident with even casual observation, thus scope for negative interaction does indeed exist. The magnitude of this interaction is the subject of a current study.

The impact of invasive species on Atlantic whitefish is uncertain, therefore the security of this species within its known distribution is also unknown. This is an important factor to consider when assessing the allowable harm caused by human activities within Minamkeak, Milipsigate, and Hebb lakes.

Relative Rank Effect

The current relative rank effect of invasive species on Atlantic whitefish is assessed high (RRE =1). Equivalent research conducted in temperate Canadian lakes support an expectation of increased mortality of Atlantic whitefish within the Petite Rivière. The RRE of invasive species will require:

1) ongoing assessment as smallmouth bass colonize all of the lakes currently supporting Atlantic whitefish,
2) reassessment should chain pickerel be introduced in the Petite Rivière, or
3) should plans to repatriate Atlantic whitefish to the Tusket and Annis rivers proceed. The scope for negative interaction with both smallmouth bass and chain pickerel will require consideration.

Mitigation

Efforts to increase awareness among the public of the potentially negative consequences that result from illegal introductions of non-native fish species are ongoing and will have to remain so. It is uncertain, at present, if measures to control abundance of smallmouth bass or chain pickerel in lakes can be developed. Regardless, control measures should be explored.

Scientific Research

Scientific research activities are a known source of Atlantic whitefish mortality. Small numbers of fish are removed from the wild, lake resident population to support captive breeding programs at the DFO Mersey Biodiversity Facility. Maintenance of a captive population may require removals from the wild of up to 20 fish in some years (S. O’Neil, DFO, Dartmouth, personal communication). Past removals of Atlantic whitefish were undertaken despite the known risks involved on the basis that recovery will only be effected through range extension. This is unlikely to occur through natural processes, and will likely require stocking captive spawned and reared fish into sites selected to receive Atlantic whitefish.

Recovery activities will require sampling the wild population of Atlantic whitefish to establish a quantitative estimate of abundance, and to support research aimed at species recovery generally. For example, monitoring will be required to assess the response of Atlantic whitefish to the presence of smallmouth bass, both in Minamkeak Lake, and as smallmouth bass colonize Milipsigate and Hebb lakes. Sampling and assessment protocols may include mark-recapture (tagging) and trapnetting, both of which could be expected to result in handling mortality to some degree.

Relative Rank Effect

The relative rank effect of scientific research on Atlantic whitefish mortality is assessed high (RRE =1). Broodstock removals represent a known, absolute loss of individuals to the wild population. Mortality has likely occurred and will likely continue to occur as a result of handling fish sampled from, and subsequently returned to, the wild.

Mitigation

There are no alternatives to scientific research. Fulfilment of recovery objectives will require further permanent removals of Atlantic whitefish from the wild, in low numbers, to support captive rearing. Monitoring activities, although based on live capture techniques, will likely result in the death of some individual fish. Efforts to improved live sampling techniques and protocols are ongoing. It is expected that range extension will result in an absolute net increase in abundance.

Military Activities

There are no active military operations in the current area of occupancy of Atlantic whitefish. Military activities are accordingly assessed as Not Applicable (RRE =NA).

NON-DOMESTIC SOURCES OF HUMAN-INDUCED MORTALITY

Long Range Transport of Air Pollutants

Air pollutants originating from industrial activities both inside and outside Canadian boundaries can result in acidic precipitation which acidifies rivers and lakes to a degree that is toxic to fish. While there may not be a current direct cause and effect relationship between air pollution and the mortality of individual Atlantic whitefish, the cumulative effect of this source of harm should be considered in determining the level of mortality allocated among other sources.

The Petite (Fig. 2), Carleton and Tusket rivers (Fig. 3) originate within, and flow through the Southern Upland of Nova Scotia. This geological formation is underlain by poorly weatherable slates and granites which produce soils that are naturally low in base cations. As a result, the area is especially vulnerable to the effects of acidification (Clair et al. 2004).

Clair et al. (2004) forecast future chemistry changes in these and 37 other rivers/ tributaries in Nova Scotia using a model of acidification of groundwater catchment

(MAGIC) and among other inputs, water chemistry determined for the year 2000. Input data were:

	pH	ANC	DOC	Ca^{+2}
Carleton	5.7	38.7	16.6	61.6
Tusket	5.0	45.2	42.8	61.5
Petite	5.7	50.5	25.7	62.4

where a pH of 5.1 - 5.4 is, with the exception of the occasional episodic event (<5.1), adequate for sustaining fish (Atlantic salmon) populations (no stages of Atlantic salmon are affected at pH >5.4); ANC is a measure of the water's capacity to neutralize acidity; Ca^{+2} is important to osmoregulation and bone maintenance processes in fish and construction of invertebrate shells; and DOC is dissolved organic carbon.

Forecasts at an anticipated 10% reduction in SO_4 emissions over the next century (Clair et al. 2004) suggest that water quality will remain best on the Petite Rivière, followed closely by the Carleton and distantly by the Tusket River. On the Petite and Carleton, pH will continue at >5.4; ANC now >50 eq L^{-1} on the Petite and increasing from 25 - 50 to >50 eq L^{-1} on the Carleton by 2040, and Ca^{+2} declining to -5 to -15% of pre-acid industrial conditions by 2015 on the Carleton and 2040 on the Petite. The Tusket is expected to remain pH 5.1 - 5.4 through 2060, ANC to be >50 eq.L^{-1} by 2015 and Ca^{2+} to continue at the presently depressed -5 to -15% of pre-industrial levels. The impact of reduced Ca^{+2} on the ecosystem and Atlantic whitefish in particular, was not assessed directly by Clair et al. (2004).

Relative Rank Effect

The current relative rank effect of air pollutants, namely acid precipitation, on Atlantic whitefish mortality is assessed low (RRE =3). The existing population of Atlantic whitefish in the Petite Rivière has remained self-sustaining during the recent past and currently. The buffering properties of the native soils in the drainage are considered adequate to maintain water acidity above levels toxic to salmonids in the majority of the watershed. Acid tolerance will be a consideration should plans to repatriate Atlantic whitefish to the Tusket River proceed.

Mitigation

No mitigation is required at this time.

CONCLUSION

There are no data available to support quantitative assessment of the maximum human-induced mortality that Atlantic whitefish can sustain and not jeopardize survival or recovery. However, the weight of accumulated evidence indicates that the mortality arising from all human activities occurring within the portion of Petite Rivière currently occupied by Atlantic whitefish do not threaten their survival or recovery.

There is uncertainty that additional human-induced harm could be sustained by Atlantic whitefish within their current area of occupancy (~16km^2 of aquatic habitat; Bradford et al. 2004), their survival is therefore subject to elevated risk from random processes. This represents uncertainty about the scope for incremental increase in human-induced harm beyond current levels.

ACKNOWLEDGEMENTS

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TABLES

Table 1. Fisheries in, or in vicinity of, the Petite Rivière drainage and the corresponding regulations that have a bearing on the potential for harm to the Atlantic whitefish (MPFR, Maritime Provinces Fishery Regulations; AFR =Atlantic Fishery Regulations, 1985; ACFLR, Aboriginal Communal Fishing Licences Regulations).

<table>
<tr><th>Waters</th><th>Regulations</th><th>Fishery</th><th>Species</th></tr>
<tr><td rowspan="5">Inland waters</td><td rowspan="5">MPFR</td><td>Recreational angling</td><td>• salmon
• trout
• smallmouth bass
• white/yellow perch</td></tr>
<tr><td>Recreational dip nets</td><td>• gaspereau
• smelt</td></tr>
<tr><td>Recreational pots/ traps</td><td>• eels</td></tr>
<tr><td>Commercial dip nets</td><td>• gaspereau</td></tr>
<tr><td>Commercial weirs/traps/pots</td><td>• eels</td></tr>
<tr><td rowspan="8">Tidal waters</td><td rowspan="5">MPFR</td><td>Recreational angling</td><td>• salmon
• trout
• smelt</td></tr>
<tr><td>Recreational dip nets</td><td>• gaspereau
• smelt</td></tr>
<tr><td>Commercial dip nets</td><td>• gaspereau</td></tr>
<tr><td>Commercial weirs/ traps/ pots</td><td>• eels</td></tr>
<tr><td>Commercial gill nets</td><td>• smelt</td></tr>
<tr><td rowspan="2">AFR</td><td>Recreational angling</td><td>• groundfish
• mackerel</td></tr>
<tr><td>Commercial gill nets</td><td>• gaspereau
• herring
• mackerel
• groundfish</td></tr>
<tr><td>ACFLR</td><td>Aboriginal communal licences</td><td>• food/social/ceremonial
• commercial (sale)</td></tr>
</table>

Table 2. Fisheries in, or in vicinity of, the Tusket-Annis rivers drainages and the corresponding regulations that have a bearing on the potential for harm to the Atlantic whitefish (MPFR, Maritime Provinces Fishery Regulations; AFR =Atlantic Fishery Regulations, 1985; ACFLR, Aboriginal Communal Fishing Licences Regulations).

Waters	Regulations	Fishery	Species
Inland waters	MPFR	Recreational angling	• salmon • trout • smallmouth bass • white/yellow perch • pickerel
		Recreational dip nets	• gaspereau • smelt
		Recreational pots/traps	• eels • tomcod
		Commercial dip nets	• gaspereau
		Commercial weirs/traps/pots	• eels
Tidal waters	MPFR	Recreational angling	• salmon • trout • smelt
		Recreational dip nets	• gaspereau • smelt
		Recreational pots/traps	• eels • tomcod
		Commercial dip nets	• gaspereau
		Commercial weirs/traps/pots	• eels
		Commercial gill nets	• smelt
	AFR	Recreational angling	• groundfish • mackerel
		Commercial gill nets	• gaspereau • herring • mackerel • groundfish
	ACFLR	Aboriginal communal licences	• food/social/ceremonial • commercial (sale)

Table 3. NSPI dams located on the Tusket River. Flows designated as --- indicate no legal requirement to provide water for fish passage. The information is based upon a review of internal DFO documents and description of best-effort practices provided by NSPI.

Location	**Requirement**	**Time Period**	**Flow (cfs)**	**Description**
Vaughn Dam	To river	1-30 April	75	Ladder plus spillway; **fishway alone is 8cfs?**
		1-31 May	150	
		1 June -15 July	75	
		16 July–15 November	20	
		16 November-31 March	0	
	Fish ladder	1 April–15 November	---	As proven for salmon and gaspereau
Powerhouse	Fish Ladder	1 April–15 November	10	
		16 November-31 March	0	
	Downstream[2]	1 April–15 November	10 - 30	
		16 November-31 March		
Carleton[1]	Ladder	1 April–1 July (or later)	---	No legal requirement, best-effort basis
	Sluice	July-August	--	Mitigate impediments to fish passage
	Sluice	September-October	---	Mitigate impediments to downstream passage of juvenile gaspereau

[1] Managed with the objective to maintain conditions which are optimum for fish passage, (subject to run-off conditions, system demands, maintenance requirements or other operational considerations (DFO)).
[2] Flow through the '4th Bay' downstream bypass shall be set at 30 cfs based on the full supply level for the Tusket Headpond and will vary as the headpond level fluctuates, never to decrease below 10 cfs.

FIGURES

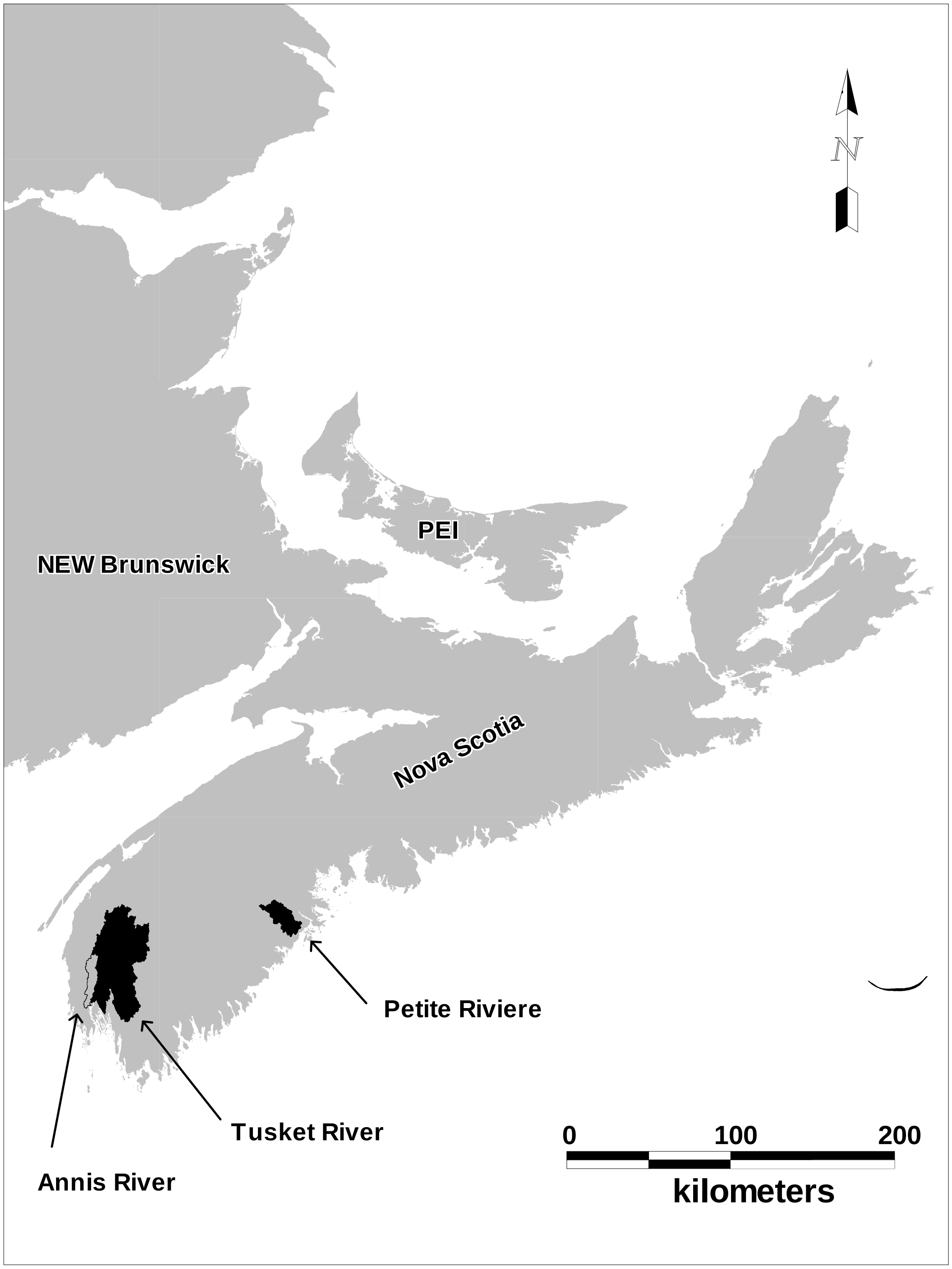

Figure 1. Location of Tusket-Annis and Petite Rivière drainages.

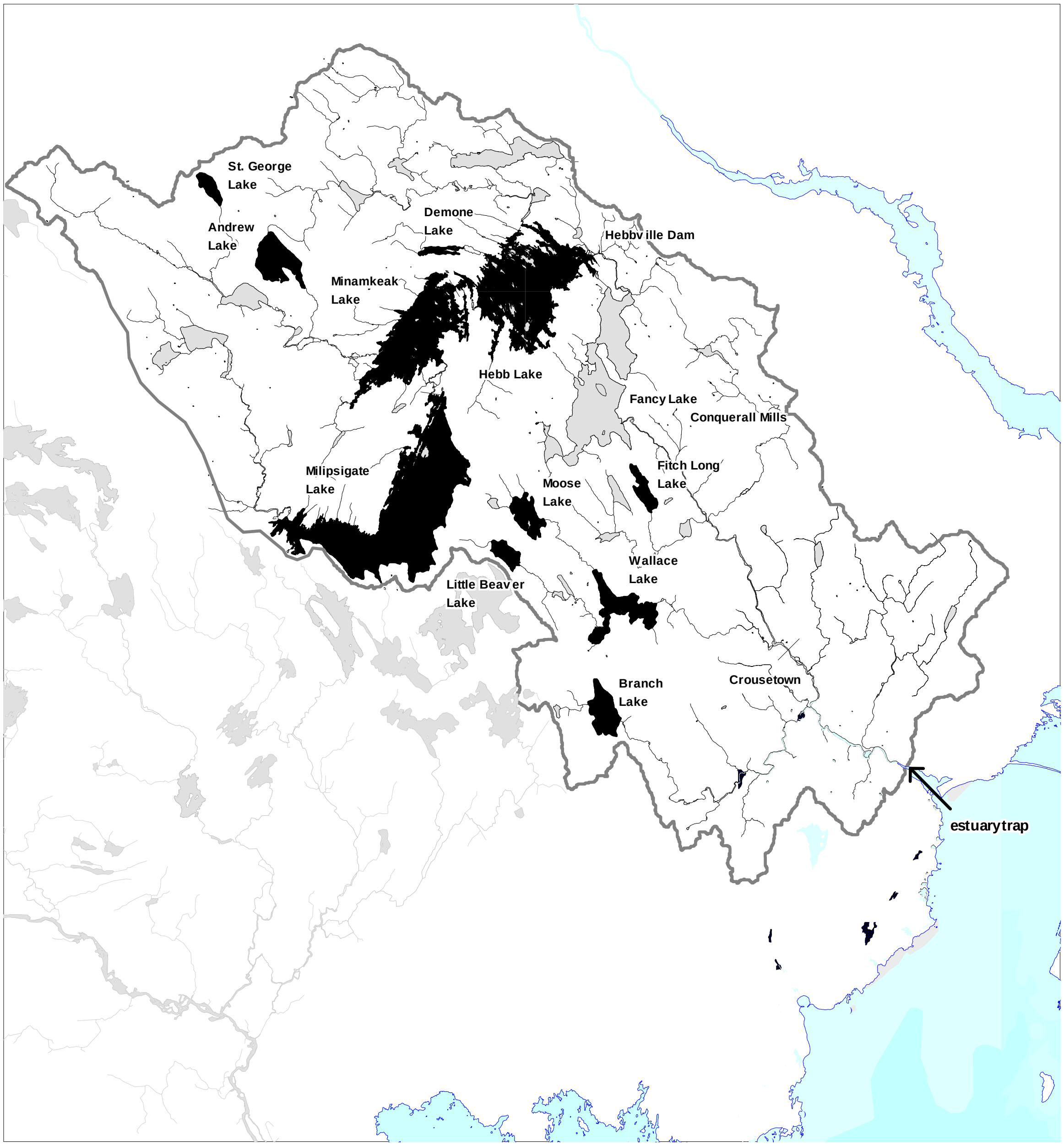

Figure 2. Lakes and place names within the Petite Rivière drainage. Lakes represented in dark shade have been surveyed to define their fish assemblages.

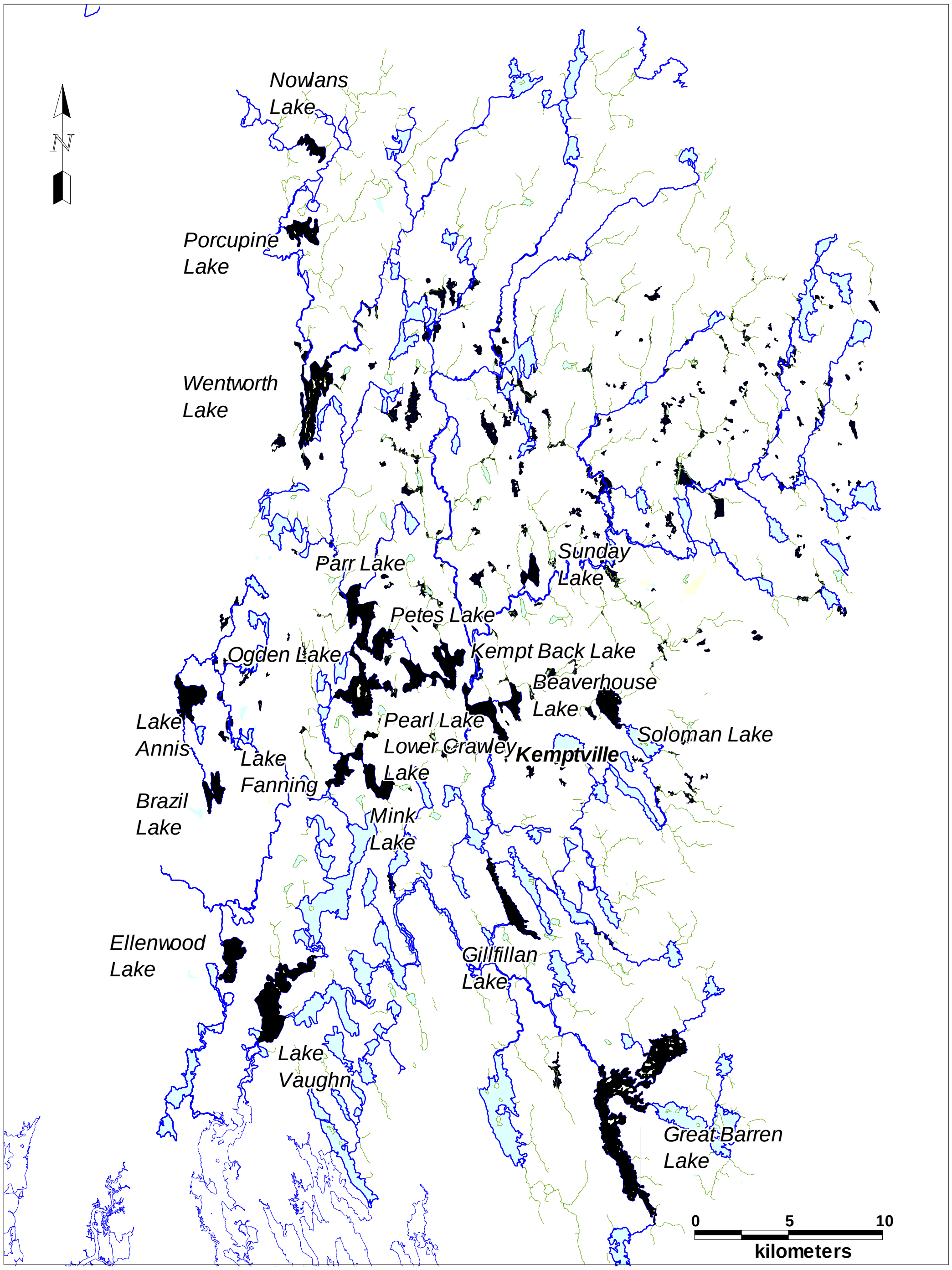

Figure 3. Lakes, river branches, and place names within the Tusket and Annis river drainages. Lakes represented in dark shade have been surveyed to define their fish assemblages.

APPENDICES

Appendix I. Record of issues and concerns, contained in internal DFO documents, with the adequacy of upstream fish passage around hydroelectric facilities on the Tusket River since construction of the Power House dam and Diversion dam in 1929.

Year(s)	Power House Fishway	Spillway (Vaughn) fishway
Dec.1929, Jan. 1930	Dam and fishway construction completed.	Dam and fishway construction completed (presume roughly same time as Power House).
Jan1930-April 1931	Fishway in place, but not functioning for upstream migration during this period. Presume no fish passage at this time.	
April/May 1931	Fishway reconstructed April 1931. Used by gaspereau. Not used during high water. Presume fish passage is intermittent during this period.	Fishway working well for gaspereau. May not be adequate for salmon. Presume has been the same since construction
July – Aug. 1931		Part of fishway rebuilt.
June – July 1932		Insufficient water below the spillway to attract salmon
Nov.,1933		Wing wall constructed downstream from dam. Salmon passing successfully.
June, 1934		Additional attraction water provided. Salmon passing successfully.
April, 1935		Fishway exit width enlarged. Salmon passing successfully. Presume passage remains successful over this period.
1937 - 1938	Fishway ineffective. Needs repair. Presume negligible fish passage.	
May 1938	Fishway minimally repaired to allow fish passage	
Summer 1939	More repairs required, but still functioning fairly well for gaspereau. Not used by salmon.	
Oct., 1939	Fishway repaired (confirm)	
1939	Presume fishway still functioning fairly well for gaspereau. Several studies indicated it is not being used by salmon.	
July 1940		Fishway needs repair. No record of repair work completed.
April – Dec. 1945		Many salmon using fishway. Presume this continues over this period.
October 1947	Entrance of existing fishway moved further downstream & self-adjusting weir installed.	
October 1947 –July 2, 1949	Changes made were ineffective. No specific data on use by gaspereau or salmon during this period. Fishway described as having only ever been useful as a downstream sluice and for ascending gaspereau.	
July 1949 – August 1950	New run-around fishway construction completed. Several problems with design, but gaspereau and salmon are using fishway.	
Late 1950 – early	Some improvement work completed, but not all that was recommended. Presume	

Year(s)	Power House Fishway	Spillway (Vaughn) fishway
1951	fish still using the fishway.	
1951 - 1964	More requests for improvement work, but nothing on file to document works completed. Presume fish still using the fishway.	
July 1964	Fishway inadequate, semi-efficient, and requires replacement. Nothing on file to document works completed. Presume fish passage is poor.	Fishway inadequate, semi-efficient, and requires replacement. Nothing on file to document works completed. Presume fish passage is poor during this period.
April 1976	200 Atlantic whitefish seen above the fish ladder. They are making use of the fish ladder (Gilhen, 1977). Nothing to indicate fish passage has improved since 1964.	
June 1977	First record of both upstream and downstream passage facilities. Construction times unknown.	
September, December 1977	Fishway ineffective for fish passage and hampered by tidal fluctuations. Fish still, however, use this route during low tide/low flow. Gaspereau use fishway. Salmon reported to use fishway in June & July. Others report that salmon not using fish ladder and not reaching habitat upstream (Gilhen 1977). Presume fish passage intermittent.	River flow and pool area at base of fishway too low and attraction water levels insufficient. Alewife still, however, are reported to use the fishway successfully, as are salmon in June and early July. Stoplog sections may provide upstream access during spring and fall spills. Presume fish passage intermittent during this period.
September 29, 1978	New fishway constructed. Request that flow be maintained in winter to prevent damage from freezing.	
1978 - 1995	No reports on use by fish. Presume operating successfully.	
February 22, 1994	Flow regulated with automatic gate at headpond.	
May 8, 1995		Fishway has sub-standard pools, concrete baffles and floor
July 5, 1995	Concern expressed about upstream passage of elvers. No record of any improvements.	Concern expressed about upstream passage of elvers. No record of any improvements.
July – Jan. 1995		Construction of new fish ladder. Testing indicates performance is good.
March 2004	Wooden baffles need replacement. Note normal outage from November 16 – March 31st will be extended to April 15th. Presume no fish passage provided yearly between November 17 – March 30th. Years practice has been in effect?	Fish ladder opens April 1st. Described as more efficient than powerhouse fishladder: passes ~95% of the spring gaspereau run.

Appendix II. Record of issues and concerns, contained in internal DFO documents, with the adequacy of downstream fish passage around hydroelectric facilities on the Tusket River since construction of the Power House dam and Diversion dam in 1929.

Year(s)	Power House Fishway	Spillway (Vaughn) Fishway
December 1929/January 1930	Dam and fishway construction completed.	Dam and fishway construction completed (presume roughly same time as Power House). No specific information on downstream passage.
June 18, 1930	No bypass - Gaspereau pass through turbines. Mesh screens (1/2inch wire) installed.	
July 1930	Efficient downstream passage reported	
April 8, 1931	Fishway reconstruction completed	
April 14, 1931		
April 30, 1931		Fishway is working well
June 15, 1931		Suggested that fishway is not adequate passage for salmon
July – August, 1931		Part of fishway rebuilt
August 31, 1931	Small gaspereau are descending in large quantities	
April 1933	Screens replaced	
April 18, 1935		Fishway exit completed.
August 12, 1935		No spill during the week and 3 logs out for the weekend (since demand for power lower on the weekend). Works well for passing fish. No indication of how long this practice continued.
1937 – 1938	Fishway ineffective and in poor condition – in need of repair. Suggested that better downstream passage is required for migration.	
May 23, 1938	Fishway repaired.	
Summer 1939	More repairs required, but still functioning fairly well for gaspereau. Not used by salmon.	
September 20, 1939	Suggestion that screens should be cleaned more often due to severe slime build-up.	
October 13, 1939	More repairs to fishway completed - confirm	
<1940	Only one turbine in use. Fish can pass through two other sluices (Gilhen, 1977).	
1940 – 1945	Intake screens destroyed many times during periods of both light water and low waters (slime carrying).	
August – October 1947	Entrance of existing fishway moved further downstream & self-adjusting weir installed.	
August	Fishway not functioning. Young	

Year(s)	Power House Fishway	Spillway (Vaughn) Fishway
1948 - February 1949	gaspereau are forced to pass through turbines during downstream migration	
March 2, 1949	Fishway described as never having been successful except as a sluice to carry down young fish and for ascending gaspereau	
July 2 1949 – August 1950	New run-around fishway construction completed. Several problems with design, but gaspereau and salmon are using fishway.	
Late 1950 – early 1951	Some improvement work completed, but not all that was recommended. Presume fish still using the fishway.	
July 24, 1956	Screen removed to pass spent gaspereau downstream through turbines Traps at fishway exits may be blocking downstream fish passage (Note: traps were used frequently in past).	
August 6, 1956	Many adult gaspereau are killed in turbines. Mortality of young gaspereau unknown.	
January 13, 1958	Electric barrier tested to keep gaspereau away from the screens. It is generally ineffective.	
June 13, 1958	Flow down fishway is not attracting fish away from the Power House flow even under light loads. Adult gaspereau crowd and block screens leading to high mortality. Bypass channel through the un-used 4th bay is suggested for downstream passage. No record that this option was pursued.	
September 11 – 22, 1958	Netting tested to keep gaspereau away from the screens. It is generally ineffective.	
1960-61	Mortality tests conducted. Results?	
November 28, 1963	Suggestion to use spare turbine bay for downstream passage. No indication that this option was pursued.	
July 17, 1964	Fishway structures are inadequate, semi-efficient and require complete replacement. No record of any repair work completed.	
March 27, 1972	Fishway ineffective for downstream passage. Juvenile and post-spawning gaspereau are either trapped above the power house intakes or killed during their passage through the turbines. Maintenance work being completed on fishway. Suggested that the unused 4th turbine bay could be used to attract and remove juveniles and spawned fish away from	The spill section and fishway are the only provision for downstream fish passage

Year(s)	Power House Fishway	Spillway (Vaughn) Fishway
	adjacent turbine intakes. No indication that this option was pursued.	
Spring 1973	By-pass constructed for downstream fish passage via spare turbine bay to be completed before 1973 migration period.	
June 20, September 8, 1977		Proposals to divert water from spill way to entrance of the Power House upstream fishway after the gaspereau run is finished. No record of this work being complete.
1977 report (Gilhen, 1977)	Few fish use fish ladder. Adult fish killed since not enough room between turbine blades and sluice to pass safely. Local report of Atlantic whitefish plunging into turbines. Screens previously installed to protect fish have been removed because they required too much maintenance.	
December 7, 1977	Plans to reduce flow in downstream bypass (15 cfs) by half to provide additional 8 cfs for fishway entrance (for attraction water). No record if this was completed.	
February 22, 1994	Downstream fishway passes fish through the spare bay of the hydro plant with a flow rate of ~15 cfs	No flow provided for downstream passage from Nov. 16 – March 31. No record of whether or not this has been normal practice.
July 15 – January 1995		New upstream fish passage provided. Proposal for downstream maintenance flows of 20 cfs to be provided through sluiceway.

Appendix III. Record of issues and concerns, contained in internal DFO documents, with the adequacy of upstream fish passage around manmade barriers on the Petite Rivière.

Year	Crousetown	Conquerall Mills	Hebbville Dam	Hebb Lake Power House Dam (Penstock)
1885	Damn and fishway constructed – wood and stone structure			
1939		Dam constructed. Operated as a hydro facility.		
1945	Fishway repaired			
July 1968	Not a formal fishway, but allows fish passage around the dam. Water levels variable due to dam leakage.			
July, 1971		Hydrolelectric facilities permanently out of commission		Hydrolelectric facilities permanently out of commission. No upstream fish passage.
1971		Dam has spillway section and 12 foot wide gate with timber stoplogs. Fishway is 350 ft long pool and weir type. Uses a minimum of 5 cfs.	No fishway – No upstream fish passage.	
March, 1972		Fishway and dam need repair	New dam recently constructed by Town of Bridgewater at Bond's dam on Hebb Lake No upstream fish passage.	Only low flows are intended to pass though this dam.
1972		Fishway operation poor = upstream passage poor. Downstream passage over spillway. Water is released through the spill section rather than through the penstock. The only water flowing through the generating channel comes from the fishway.		

Year	Crousetown	Conquerall Mills	Hebbville Dam	Hebb Lake Power House Dam (Penstock)
		Inadequate attraction water for fish to find the fishway. Plans to construct 3 foot high fish barrier to prevent fish from entering the spillway, and a second partial dam across the generating channel to increase the attraction water. No record that this work was completed.		
1973		Improvements required to fishway structure due to changes resulting from the closing of the power station (Environment Canada, 1974).		
November 1973 – April 1974		Fishway dry or closed = no upstream passage		
Aug. Sept. 1974		Fishway dry or closed = no upstream passage		
October 11, 1974		Town of Bridgewater to abandon the dam December 31, 1974 Fishway is obsolete and dam deteriorating. Since 1973, upstream fish passage accomplished at this site by trucking gaspereau over the dam.		
August 28, 1975	Maintenance work completed on fishway: debris removed, timber over fishway removed, and above dam filling to improve storage.	Water levels and flow unacceptable (headpond empty, river flow low - not adequately maintained for fish passage). Deteriorated stop logs being replaced. No barrier screens to prevent fish from entering spillway channel. Small earth and rock dam installed in 1974 - fish migration not likely to be impeded (see entry October 1974).		
1977		Dam breached (Edge and Gilhen 2001)		