Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2016/109

Pacific Region

Information in support of the identification of critical habitat for the Cowichan (Vancouver) Lamprey (*Entosphenus macrostomus)*

Sean MacConnachie[1,] and Joy Wade[2]

[1]Fisheries and Oceans Canada
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7

[2]Fundy Aqua Services Inc
1859 Delanice Way
Nanoose Bay, B.C. V9P 9B3

December 2016

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

MacConnachie, S., and Wade, J. 2016. Information in support of the identification of critical habitat for the Cowichan (Vancouver) Lamprey (*Entosphenus macrostomus).* DFO Can. Sci. Advis. Sec. Res. Doc. 2016/109. vi + 17 p.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Critical habitat is proposed for the Cowichan (Vancouver) Lamprey (*Entosphenus macrostomus*) in Cowichan and Mesachie lakes, on Vancouver Island, British Columbia. The Cowichan Lamprey is currently listed as Threatened on Schedule 1 of the *Species at Risk Act* under the scientific name *Lampetra macrostoma*. It was recently reclassified as *E. macrostomus* by the American Fisheries Society in the 7th edition of the Common and Scientific Names of Fishes from the Unites States, Canada, and Mexico. The Cowichan Lamprey is endemic to Cowichan and Mesachie lakes and any habitat that is critical for the survival and recovery for this species should be afforded protection. Given the endemism of the species and the distribution of habitats for various life stages, the critical habitat for the Cowichan Lamprey is recommended as Cowichan and Mesachie lakes in their entirety, the adjoining waterways and 100 metres upstream of tributaries into the lakes.

Information à l’appui de la désignation de l’habitat essentiel de la lamproie du lac Cowichan (lamproie de Vancouver) (*Entosphenus macrostomus)*

RÉSUMÉ

On propose de désigner des habitats essentiels de la lamproie du lac Cowichan (lamproie de Vancouver) (*Entosphenus macrostomus*) dans les lacs Cowichan et Mesachie, sur l’île de Vancouver, en Colombie-Britannique. La lamproie du lac Cowichan est actuellement inscrite en tant qu’espèce menacée à l’Annexe 1 de la *Loi sur les espèces en péril* sous le nom scientifique *Lampetra macrostoma*. Elle a récemment été reclassifiée comme *E. macrostomus* par l’American Fisheries Society dans la 7^{e} édition de la Liste des noms communs et scientifiques des poissons des États-Unis, du Canada et du Mexique. La lamproie du lac Cowichan est endémique dans les lacs Cowichan et Mesachie, et tout habitat essentiel à la survie et au rétablissement de cette espèce doit être protégé. Compte tenu de l’endémisme de l’espèce et de la répartition des habitats nécessaires pour les différents stades biologiques, il est recommandé de désigner comme habitat essentiel de la lamproie du lac Cowichan les lacs Cowichan et Mesachie dans leur intégralité, de même que les voies navigables adjacentes et 100 mètres en amont des affluents de ces lacs.

1 INTRODUCTION

The Cowichan lamprey (*E. macrostomus*) is a freshwater parasitic species derived from the Pacific lamprey (*L. tridentata*). It has only been identified in the Cowichan and Mesachie lakes on Vancouver Island, British Columbia. Cowichan lamprey have not been found in the Cowichan River despite there being no barriers to access. There is no evidence of any other lamprey species in either of these lakes. Cowichan lamprey was deemed a separate species based on its unique morphological and physiological traits, primarily its large oral disk and physiological adaptation to freshwater (Beamish 1982). Recently, its status as a species has been confirmed genetically by Taylor et al. (2012).

In 2003, Cowichan lamprey was listed as Threatened under the *Species at Risk Act* (SARA) and a recovery strategy for the species was completed in 2007 (Vancouver Lamprey Recovery Team 2007). A recovery strategy or action plan must identify an endangered species' critical habitat, or "the habitat that is necessary for the survival or recovery of a listed species and that is identified as the species critical habitat in the recovery strategy or action plan for the species" (Species at Risk Act, 2002). Under SARA s41(1)(c) a species' critical habitat must be identified to the extent possible, based on the best available information.

This paper summarizes the best available information to support the identification of critical habitat that provides the features and functions necessary to support the life cycle-processes of for *E. macrostomus* to the extent possible. It also identifies knowledge gaps that need to be filled to complete the features, functions and attributes of the critical habitat for *E. macrostomus.*

2 POPULATION AND STATUS

2.1 SPECIES AND DISTRIBUTION

Cowichan lamprey was first described by Beamish (1982) as *Lampetra macrostoma*, a freshwater parasitic lamprey distinguished from other related species such as Pacific lamprey (*Entosphenus tridentatus)* by its freshwater parasitic nature, large oral disc and other morphological differences. The species designation of Cowichan Lamprey was recently confirmed by Taylor et al. (2012) using microsatellite DNA analysis. Originally listed under the SARA as *L. macrostoma*, the species has been reclassified as *E. macrostomus* by the American Fisheries Society in the 7th edition of the Common and Scientific Names of Fishes from the United States, Canada, and Mexico (Lawrence et al. 2013). Recent efforts have been made use the more appropriate common name of Cowichan Lamprey, which will be used in this document.

E. macrostomus is an endemic species reported only in Cowichan and Mesachie lakes, on southern Vancouver Island, British Columbia, and the lower parts of some tributaries to these lakes (Figure 1). The two lakes are adjacent and connected via the Robertson Creek, Bear Lake and an unnamed watercourse, sometimes referred to as Mesachie Creek (Figure 2).

There are no complete barriers to fish movement into and out of Cowichan Lake, as evidenced by the use of the lake and tributaries by anadromous salmon for spawning and rearing. There is a weir located at the outlet of Cowichan Lake to Cowichan River which is used to regulate the amount of water in the river and/or lake; however it does not pose a complete barrier to fish movement. *E. macrostomus* has not been observed downstream of Cowichan Lake, however, there is no reason to believe there is a physical barrier to their movement. Conversely, Mesachie Lake can, at some times of the year, become isolated from Cowichan Lake due to low water.

Spawning lamprey have only been observed in Mesachie Lake. Spawning locations in Cowichan Lake remain to be identified. Ammocoetes have been found in Mesachie Lake and several locations in Cowichan Lake and associate tributaries. Lamprey scars and wounds on salmonids, most commonly but not exclusively on Cutthroat Trout (*Oncorhynchus clarkii*), has been seen and continues to be reported in both Mesachie and Cowichan lakes. Predation has been reported on juvenile Coho salmon (*O. kisutch*) in the past (Beamish and Wade 2008). However, this may be explained by the earlier practice of rescuing pool-bound Coho salmon and placing them en-masse in Mesachie Lake. It is believed that the only species of lamprey present in Cowichan and Mesachie lakes is *E. macrostomus*, although anecdotal reports of "large" lamprey attached to salmonids have been made by recreational fishermen fishing in Cowichan Lake. Although it is difficult, but not impossible to visually distinguish between *E. macrostomus* and *E. tridentatus* ammocoetes, preliminary genetic analyses of samples collected in 2012 in Cowichan Lake confirmed the visual identification. That is, all ammocoete samples tested were genetically similar to each other and no genetic differences could be identified between adult *E. macrostomus* and ammocoetes. Therefore all animals tested were confirmed to be *E. macrostomus*. Additional samples of adult DNA are however required. Currently, it is believed that all lamprey in Cowichan and Mesachie lakes are *E. macrostomus*.

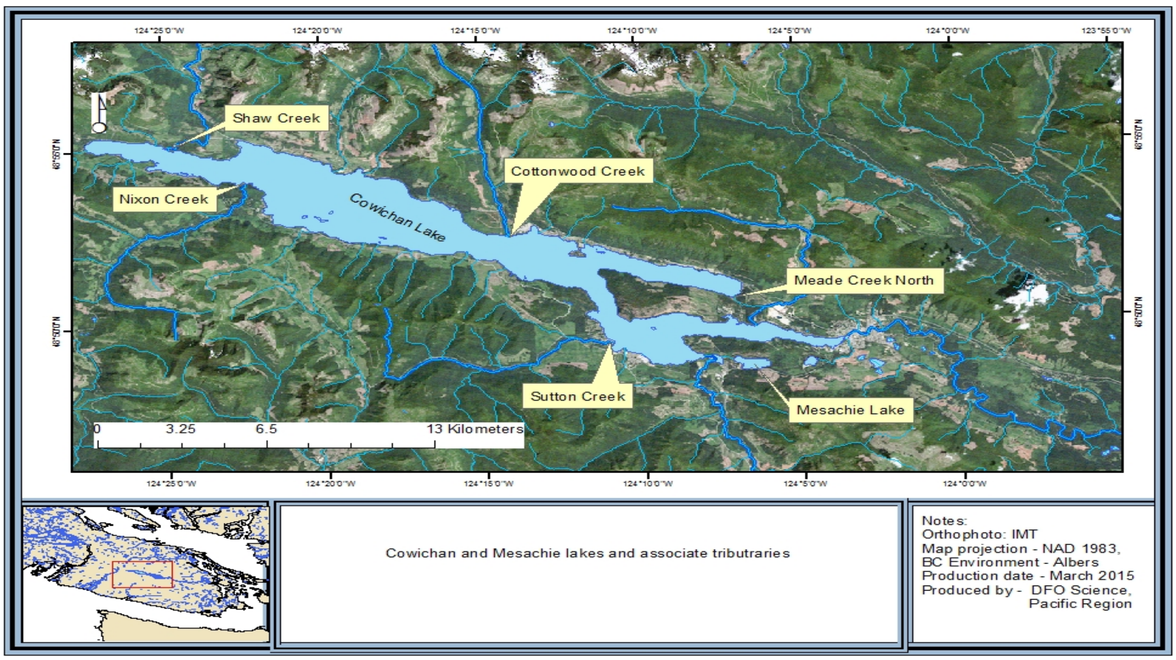

Figure 1. Cowichan and Mesachie lakes. Proposed critical habitat includes both lakes, adjoining waterways and 100 metres up stream of inflowing creeks.

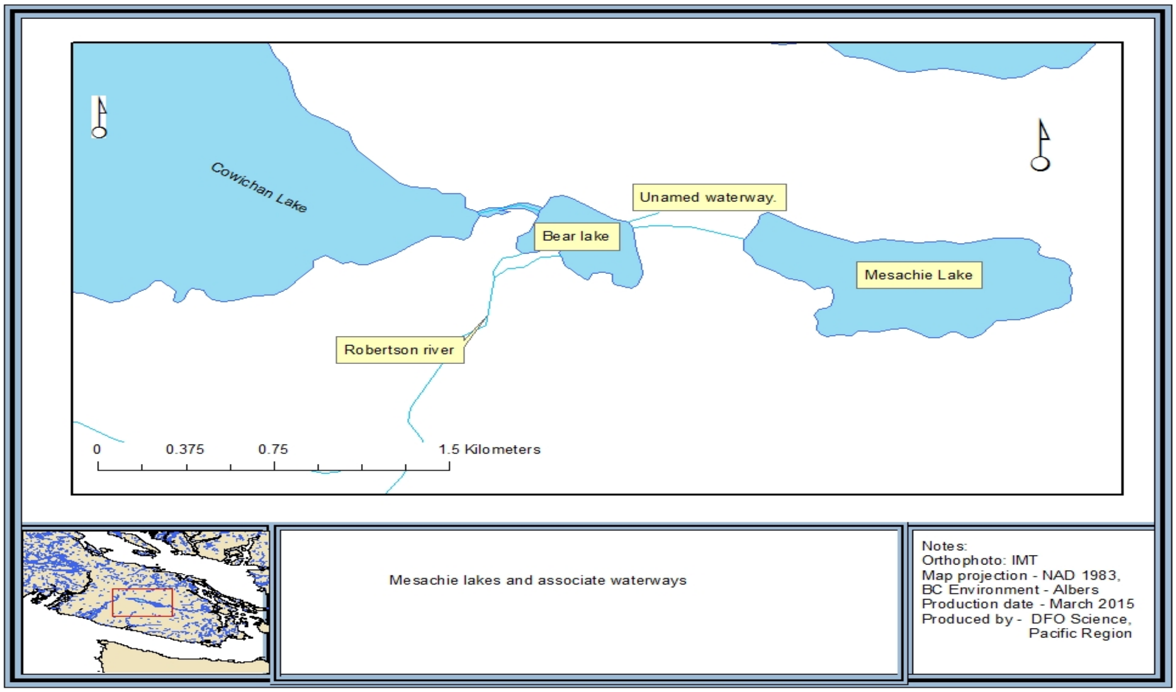

Figure 2. Cowichan and Mesachie Lakes with connecting waterways

2.2 ABUNDANCE

Since the species was first described in the 1980s, there have been several small studies of the general biology of the species but very little contribution to the determination of population abundance and no efforts to determine habitat-specific abundance. The incidence of lamprey-induced scarring and wounding on salmonids implies that abundance fluctuates (Beamish 1998). The magnitude and frequency of fluctuations remains unknown, however it is expected that parasitic lamprey populations fluctuate in response to prey availability (Beamish 1998). At present, the current data cannot allow for any determination of decline, maintenance or increase in population abundance.

Beamish (1998) provided a guess of an abundance of 1,000 to 2,000 adults in Mesachie and Cowichan lakes. Results of a trapping study in Mesachie Lake suggest the population in that lake may have declined since the 1980s (Beamish and Wade 2008). In addition, informal records from an annual Mesachie Lake fishing derby suggested a decrease in catch rate over a 30 year period (Beamish and Wade 2008).

Further work is required in Mesachie Lake, Cowichan Lake and its tributaries to determine relative abundance and to be able to determine fluctuations in population size. Relative abundance estimates for lamprey are not easy to determine. It is possible to determine ammocoete abundance in defined sampling areas and, periodically (every 2-3 years) repeat the counts to determine relative abundance over time. In addition, it may be possible to quantify and qualify lamprey scars on salmonids and use that data to estimate relative abundance of lamprey in a given lake. Using scars as an indirect measure of lamprey abundance would however have significant constraints such as estimating the duration of time a lamprey spends attached to a prey, how much time they spend free swimming and, mortality rates of prey due to scarring.

3 INFORMATION SOURCES

Although early efforts were made to identify and recognize *E. macrostomus* as a distinct species (Beamish 1982) relatively little work has been undertaken since then that better describes the biology of the animal, its ecological role and habitat requirements. The bulk of the information used to recommend critical habitat stems from previous works (Beamish 1982, 1986, 1998; Beamish and Wade 2008, COSEWIC 2000, 2008; Vancouver Lamprey Recovery Team 2007). This document encapsulates this information in order to respond to the needs of the DFO Species at Risk program to identify critical habitat for this species. Further refinement of critical habitat will require filling in knowledge gaps for this species.

4 COWICHAN WATERSHED

Cowichan and Mesachie lakes are both oligotrophic; a nutrient status typical of coastal lakes in British Columbia (Vancouver Lamprey Recovery Team 2007). The Cowichan Valley experiences a variable climate that is generally warm and dry in summer and mild and wet in winter (Vancouver Lamprey Recovery Team 2007). Cowichan Lake is considered a monomictic lake as it does not freeze and circulates freely in the winter at or above 4^{o}C and only stratifies in the summer (BC Lake Stewardship Society 2014).

Cowichan Lake is at an elevation of approximately 164 m emptying into Cowichan River through a controlled weir. The lake is one of the largest bodies of freshwater on Vancouver Island with a surface area of 6,204 ha and a perimeter of 110 km. The lake bottom drops off quickly from the shore to an average depth of approximately 50m and a maximum depth of 152 m (Cowichan Watershed Board). It is boarded by steep mountains and a rocky shoreline providing little cover for fish species (BC Lake Stewardship Society 2014). The entire Cowichan watershed has a catchment area of 930 km^2, less than half of which being attributed to Cowichan Lake. Despite the relatively small proportion of the catchment area, Cowichan Lake receives more than 2.5 times the annual precipitation of the lower catchment (Cowichan Watershed Board). Heavy rainfalls are common in November in the Cowichan watershed with water from above Lake Cowichan reaching the ocean at Cowichan Bay within hours of falling (Cowichan Watershed Board). The western and upper half of the watershed is marked with high precipitation, high recharge and storage with a very low human population and low water demand, the converse is true in the eastern and lower half of the watershed where there is low water supply and high demand (Cowichan Watershed Board).

Cowichan watershed is a heavily utilized, multi-user watershed. There are approximately 6,000 people living in the Cowichan Lake area alone, with several thousand more visitors in the summer months. Anthropogenic activities in and around Cowichan Lake include timber harvesting, recreational fishing, residential development and recreation (boating, camping). The Cowichan region is a rich agricultural area with a high potential for increased agricultural development with 80% of the arable land in the watershed requiring irrigation (Cowichan Watershed Board). Cowichan Lake is also the water source for the Town of Lake Cowichan and is a reservoir in support of the ecological and anthropogenic functions of the Cowichan watershed.

In order to balance many of these water requirements, a one metre tall weir was constructed in 1957 between Cowichan River and Cowichan Lake to control water flow in the late summer and early fall when river discharges commonly fall below the demands downstream (Cowichan Watershed Board). Between late fall and early spring the weir is referred to as an “off control” as the lake level is above the top of the weir and serves little function as water control structure. The weir has two main functions

1. to maintain a flow rate or discharge rate in the river above 7 m3/s and

2. to maintain sufficient water in Cowichan Lake as long as possible.

In the late summer it is not normally possible to satisfy both objectives and operational judgement is made based on lake level, discharge rate in Cowichan River, salmon priorities and rainfall predictions (Cowichan Watershed Board). The weir is currently managed by Catalyst Paper. Specific protocols on how and when the weir is adjusted can be found in the Cowichan Weir Start-Up, Operation and Seasonal Protocols (Vessey et al 2008).

Commercial logging occurred along the shore of Cowichan Lake as early as 1879, prior to the first settlement and continues today. In February 1912, the E & N railway reached Cowichan Lake and a logging boom began. As the easily accessible timber supply dwindled, logging moved higher into the upper Cowichan watershed (Cowichan Lake District chamber of commerce: CLDCC). As a result of declining local employment in the forest industry, the Cowichan Lake Community Forest Cooperative was incorporated in 1995. Their current Forest License is volume based at 3000 hectares on the Bolduc Block near Gordon River. In addition to this license, large companies are still logging in the area, though much of the tree removal occurs on private lands, governed by the Private Managed Forest Land Act.

Mesachie Lake is located at the eastern end of Cowichan Lake and has a surface area of 59.3 hectares. Anthropogenic activities affecting this lake include fishing, boating, the development of residential homes and recreational properties. Beamish and Wade (2008) provide a thorough description of recent changes to anthropogenic activities along the shores of Mesachie Lake.

Cowichan Lake contains many salmon species including Chinook (*O. tshawytscha*), Coho (*O. kisutch*) and Chum (*O. keta*) salmon as well as populations of sea run steelhead (*O. mykiss*) and Cutthroat Trout. Resident species include brown trout (*Salmo trutta*), Dolly Varden (*Salvelinus malma*), Rainbow Trout (*O. mykiss*), Cutthroat Trout and Kokanee Salmon (*O. nerka*). Other fish species found in Cowichan Lake include Smallmouth Bass (*Micropterus dolomieu*), Prickly Sculpin (*Cottus asper*) and Threespine Stickleback (*Gasterosteus aculeatus*).

5 KEY LIFE STAGES AND HABITAT NEEDS

5.1 SPAWNING AND EGG INCUBATION

It is only during the spawning period that adult *E. macrostomus* is easily studied. It is at this time that mature lamprey inhabit nearshore areas of Mesachie and Cowichan lakes around fluvial planes. Beamish (1985) indicated that they did not utilize streams for spawning like other lamprey species such as *E. tridentatus*. However, ammocoetes have been found in the lower portions of some tributaries (Beamish 1982; Wade 2011[1], 2012[2]), indicating that either spawning can occur in these tributaries or that the ammocoetes move upstream. Beamish (1998) describes spawning aggregations on shallow gravel deltas near the mouth of tributary creeks, in water depths of 0.2 to 2 m. Distribution of spawning animals into deeper habitats has not been investigated.

The spawning season for Cowichan Lamprey is May to August and during this time animals create depressions in the sediment to serve as nests for egg fertilization and incubation. Like all lamprey

[1]Wade, J. 2011. Cowichan Lake Lamprey Habitat Survey. Field Survey Final Report 2011. Submitted to Sean MacConnachie, DFO, Pacific Biological Station, Nanaimo, BC

[2] Wade, J. 2012. Cowichan Lake Lamprey (*L. macrostoma*) Habitat Use. Field Survey Final Report 2012. Submitted to Sean MacConnachie, DFO, Pacific Biological Station, Nanaimo, BC (Accessed September 14, 2016)

species, *E. macrostomus* spawns only once and dies shortly thereafter (Beamish 1998). Eggs incubate in these depressions until they hatch as ammocoetes.

5.2 AMMOCOETES

After hatching, it is believed that lamprey ammocoetes drift a short distance from the nest, where they burrow into soft fine sediments or sand (Scott and Crossman 1973). Larval habitat is thus generally defined as fine sediment areas in close proximity to lake tributaries, but the depth and spatial distribution of larval habitat remains poorly understood. Taylor et al (2012) were limited to electrofishing at depths of no more than 120 cm, but ammocoetes were found up to this maximum depth. Habitat that appeared suitable for ammocoetes was found beyond this depth, but dredging would be required to determine the maximum depth distribution of *E. macrostomus* ammocoetes (Harris pers. comm. 2007 in Vancouver Lamprey Recovery Team 2007). Wade (2012) also indicated that ammocoetes are found in these types of substrates but they are also found in loose muddy sediment away from any visible input from creeks or rivers.

From 1980 to 1982, ammocoetes were collected in the shallow silt covered areas near the mouths of Nixon Creek, Shaw Creek, Cottonwood Creek and the outlet of Meade Creek (Figure 1) (Beamish and Wade 2008). However, they were seldom found at distances greater than 100 m upstream from the lake (Beamish 1982). Electroshocking surveys in Cowichan Lake in 2011 (Wade 2011) and again in September 2012 (Wade 2012) identified areas where ammocoetes were found within the depth constraints of a backpack electroshocker. The entire perimeter of Cowichan Lake was surveyed for ammocoete habitat suitability and possible locations (>20) were electroshocked to determine presence/absence of ammocoetes. Ammocoetes were found in the following eight areas around Cowichan Lake: Meade's Creek north; Sutton Creek; Robertson Creek; the old motel area; Hawes Bay; Shaw Creek; Nixon Creek and; the float house near Nixon Creek (Wade 2012). At six of eight locations, ammocoetes were deemed too many to count (TMTC) in a time span of less than 10 minutes of active electroshocking. It could be inferred that areas where extremely small ammocoetes were found (< 2-3 cm, Figure 3) may be spawning locations or very close to spawning locations. The habitat in these locations varied significantly from low flow boggy areas with high organic deposits (old motel area and float house area) to outflow areas of creeks and streams with substrates composed mostly of small pebbles and gravel.

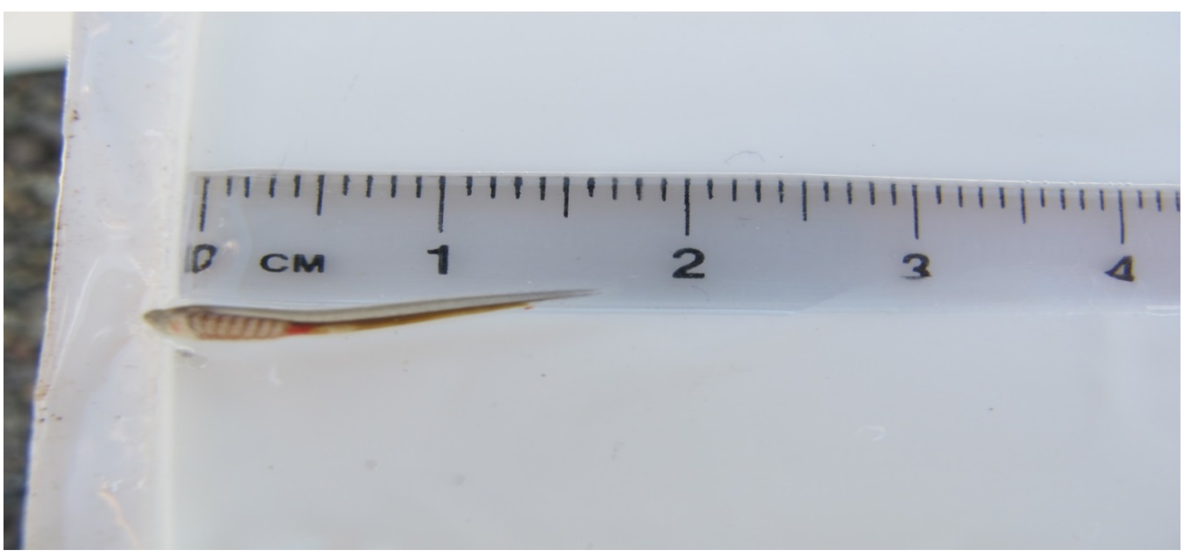

Figure 3. Cowichan Lamprey ammocoete found during electroshocking in Cowichan Lake (photo credit Joy Wade).

It is not known how long an ammocoete spends at this life stage before undergoing metamorphosis. Beamish (1998) estimates that this species could spend up to six years as an ammocoete and up to two years post-metamorphosis before death. Interestingly, field survey results in 2012 did show a large range in ammocoete sizes in some locations. For example, Nixon Creek ammocoetes were ranged from 4.2-13.2 cm with an average length of 10.9 cm (Wade 2012). Such a wide range of sizes is indicative of numerous year classes occupying the same habitat at the same time, keeping in mind that ammocoetes are not sessile.

5.3 METAMORPHOSING AND ADULT LAMPREY

Beamish (1985) describes recently metamorphosed *E. macrostomus* with an average length of 11.7cm and adults ranging in size from 18 to 27 cm (Figure 4). The considerable growth that occurs from recently metamorphosed individuals to adult size indicates that the species is an obligate parasite (Beamish 1985). This is not surprising as it has been seen parasitizing salmonid species such as cutthroat trout in Cowichan and Mesachie lakes; the scarring evidence left on these fish is also evidence of parasitism by lamprey (Figure 5).

Figure 4. Adult Cowichan Lamprey (photo credit Joy Wade).

Figure 5. Evidence of lamprey predation on Curthroat trout from Cowichan Lake (photo credit Joy Wade).

Two metamorphosing lamprey, 12.3 cm and 12.7 cm in length, were captured in electroshocking surveys at the mouth of Robertson Creek in September 2012 (Wade 2012). Ammocoetes electroshocked at this same time and location were deemed “too many to count” (TMTC) with a large proportion being very small ammocoetes (<5 cm) (Wade 2012).

Metamorphosis occurs from July to October; young adults likely remain in the substrate until the following spring (Beamish 1998). Active feeding in adults is thought to commence during the spring after metamorphosis and continue until just before spawning, the following spring or summer (Beamish 1982). Feeding adults readily prey upon live fish (Beamish 1982), and many fish collected in Cowichan Lake show scarring and wounds from lamprey (Carl 1953; Beamish 1982). Little is known about *E. macrostomus* biology between the time of metamorphosis and spawning. Active feeding occurs in the warmer months, and considerable growth occurs from metamorphosis to time at spawning (Beamish 1982). The habitat requirements of this life stage are not known.

6 CRITICAL HABITAT

Critical habitat is defined in the Species at Risk Act (2002) section 2(1) as “the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species”.

The SARA defines habitat for aquatic species at risk as "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [s. 2(1)]

Ideally critical habitat will be identified based on a range-wide analysis of the amount, locations, and attributes of habitat required to meet the population and distribution objectives for the species. However, in the absence of range-wide information, critical habitat must be identified to the extent possible, based on the best available information. In such cases, critical habitat can be partially identified i.e. identified in areas where adequate information is available (DFO 2008).

It is important to note that despite the use of the term critical habitat in this paper, critical habitat for *E. macrostomus* will only be legally identified once it is included in a final recovery strategy or action plan for the species that is posted on the SARA Public Registry.

6.1 APPROACHES TO IDENTIFYING CRITICAL HABITAT LOCATIONS AND ATTRIBUTES

The identification of critical habitat in the context of SARA must:

- Specify the geospatial location of the critical habitat or describe the area within which critical habitat is found;
- Describe the known biophysical functions, features and attributes of that critical habitat that are required by the listed wildlife species in order to carry out life processes necessary for its survival or recovery;
- Provide a sufficient level of detail to allow a person to determine whether a particular location is part of critical habitat.

There are several reasons to support the identification of critical habitat for Cowichan Lamprey as Cowichan Lake, Bear Lake, an unnamed waterway and Mesachie Lake, and 100 m upstream of inflowing tributaries with 10-30 m of riparian area around each lake and tributary. Particular considerations for this designation include the endemism of the species, the varied habitat features believed to be required by different life stages of the lamprey, and the distribution of these habitats throughout the area. The fluvial fans of some of the lakes' tributaries are believed to be where Cowichan Lamprey spawn and initial larval rearing takes place. The riparian area adjacent to the inlet streams will provide for trees to fall as LWD and SWD, leaf litter for detritus as well as maintaining bank integrity to ensure water flow and maintain sedimentation rates within natural limits. A riparian area around the lakes is also recommended as it may be a source of detritus and leaf litter that will support ammocoete rearing and growth. How a lakeside riparian component of critical habitat would benefit adult lamprey is unknown. The extent of the riparian area around the lake has only subjectively been recommended as 10-30m. A more thorough investigation into the effect of the lakeside riparian habitat should be explored or a different method be adopted to support a lakeside riparian area.

Increased development pressure in the Cowichan lake watershed could result in significant impacts to species habitat and population levels. When dealing with, what is presumed to be a very small and endemic population, any loss of habitat or individuals could have significant implications for the survival of the population.

6.2 IDENTIFYING RIPARIAN AREA WIDTH

Riparian areas play an important part in preserving and contributing to the characteristics of aquatic ecosystems. In order to define the width of the riparian area that should be included in the critical habitat being identified for Cowichan lamprey, it is recommended that the British Columbia Riparian Area Regulation (RAR) method (or some other equivalent method) be applied to Cowichan and Mesachie lakes. The results of this analysis will likely recommend an area ranging from 10-30 m depending on the characteristics of the riparian area and the waterway. This riparian area would apply to Mesachie Lake, Cowichan Lake and inter-connecting waterways.

It is recognized that the RAR method is not without its disadvantages. The primary criticism is that it is designed for salmonids in an urban setting. However, the purpose of the RAR is to "establish directives to protect riparian areas from development so that the areas can provide natural features, functions, and conditions that support fish life processes" and so ensure that "there will be no harmful alteration, disruption or destruction of natural features, functions, and conditions that support fish life processes in the riparian assessment area" (B.C. Reg. 376/2004). If other methods become available which are better suited for the determination of riparian area portion of critical habitat for this species, they can be applied to Cowichan Lake, Mesachie Lake and their tributaries.

6.3 BIOPHYSICAL FUNCTIONS, FEATURES AND ATTRIBUTES OF PROPOSED CRITICAL HABITAT FOR COWICHAN LAMPREY

The proposed critical habitat described here is believed to be necessary for the survival of *E. macrostomus*. Table 1 summarizes the best available knowledge of the functions, features and attributes needed for each life-stage for the species. Note that not all attributes in Table 1 would need to be present in order for a feature to be identified as critical habitat. If the features as described in Table 1 are present and capable of supporting the associated function(s), the feature should be considered critical habitat for *E. macrostomus*, even though some of the associated attributes might be outside of the range indicated in the table.

It is not currently possible to provide quantitative thresholds for most critical habitat attributes. Further works could be undertaken to develop an understanding of such levels and thresholds in quantifiable terms specific to this species.

The quality of the identified critical habitat is unknown but assumed to be variable, affecting local population density and reproductive success. Some areas of critical habitat are probably of lower quality due to natural variation, or the proximity of land-based activities, but they are, nevertheless, necessary for the survival or recovery of the species.

Table 1. General summary of the biophysical functions, features and attributes for E. macrostomus in Cowichan Lake, Mesachie Lake, adjoining waterways and adjacent tributaries.

Life stage	Function	Feature	Attribute
Eggs	Incubation	Nest	- Pebbles no greater than 1 cm diameter - Hard substrate covered with small pebbles/sediment - Mean depth nest into substrate mean ~ 30 cm (Stone 2006) - Water quality parameters (oxygen, temperature and pH) within the natural range of variation. - Few or no added pollutants
Ammocoetes	Feeding and rearing	Fluvial fans from streams flowing into lake habitat	- Low to medium water flow - Loose silt, sand or mud substrate - Free flowing water - Water quality parameters (oxygen, temperature and pH) within the natural range of variation - Adequate supply of detritus for food
Adults	Spawning	Fluvial fans from streams flowing into lake habitat	- Pebbles no greater than 1 cm diameter for building nests - Hard substrate covered with small pebbles/sediment - Mean depth nest into substrate mean ~ 30 cm (Stone 2006) - Water quality parameters (oxygen, temperature and pH) within the natural range of variation - Few or no added pollutants
	Feeding	Lake habitat	- Prey availability (exact species unknown) - Water quality parameters (oxygen, temperature and pH) within the natural range of variation

Nearshore Lake Habitat: Eggs

Nearshore lake habitat is the biophysical feature that supports the life cycle function of egg incubation. Cowichan Lamprey have been observed spawning in the nearshore lake areas around outlets of streams/rivers. It is possible that adults are spawning in the streams and rivers entering the lakes but this has not been confirmed.

Fluvial Fan Habitat: Eggs, Ammocoetes and Spawning Adults

Fluvial fan habitat is a biophysical feature that supports the life cycle functions of incubating eggs, ammocoetes and spawning adults. To build their nests, lamprey move pebbles surfaces and create depressions (nests) for spawning and egg incubation. The fluvial fan habitat created by streams emptying into Mesachie and Cowichan lakes provides this habitat. This area also provides for the feeding and rearing of ammocoetes. Although it is not known how long the species spends as an ammocoete it could be as long as seven years based on observations of other, similar lamprey species (Hardisty and Potter 1971, Potter 1980, Beamish and Northcote 1989). In general, ammocoetes are motile and move from place to place actively filter feeding on detritus. Recent electroshocking surveys found ammocoetes in low flow areas of fluvial fans particularly where the substrate was composed of loose silt, sand or mud (Wade 2011; 2012).

Stream Habitat: Ammocoetes

Stream habitat is a biophysical feature that supports the life cycle function of ammocoetes. Because ammocoetes are not sedentary and move from one location to another, they can and do utilize streams entering into Cowichan and Mesachie lakes. The same attributes of fluvial fans are applied to stream habitat.

Lake Habitat: Adults

Lake habitat, or the pelagic portion of the lake, is a biophysical feature that supports the life cycle functions of adult *E. macrostomus*. Which areas, or portions of the lakes, that are preferentially used by adult lamprey are unknown. It is unknown if adult lamprey stratify themselves by size, season, depth, location or some other variable during this period. The attributes of lake habitat key to the survival of the population include prey availability, water quality and water supply. It is not known if there is a preferred prey although scars and wounds have been reported on Cutthroat Trout.

7 GEOGRAPHIC IDENTIFICATION

The following locations of the functions, features and attributes of potential critical habitat for Cowichan lamprey have been identified using the bounding box approach. Critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographic boundaries where the described biophysical features and the functions they support occur. The area within which critical habitat for Cowichan lamprey occurs is identified by the map in Figure 1 and the list of coordinates in Table 2.

Table 2. Point coordinates for Cowichan Lamprey critical habitat.

Point coordinates	Latitude	Longitude
CL1	48.918	-124.416
CL2	48.901	-124.375
CL3	48.884	-124.124
CL4	48.847	-124.115
CL5	48.816	-124.135
CL6	48.813	-124.109

8 CRITICAL HABITAT IDENTIFICATION IN RELATION TO POPULATION AND DISTRIBUTION OBJECTIVES

The recovery goal for Cowichan lamprey is to secure its long-term viability within its natural range. The suggested critical habitat will support achieving this goal.

9 ACTIVITIES LIKELY TO DESTROY CRITICAL HABITAT

The recovery strategy for *E. macrostomus* highlights a wide variety of anthropogenic activities that are a concern for the recovery and survival of the species. The intensity and severity of these activities have not been quantified and will need further research to confirm the extent and likelihood of destruction of critical habitat.

Activities that are likely to permanently or temporarily destroy critical habitat for *E. macrostomus*, include, but are not limited to the following:

- **Land-based activities which have the capacity to alter aquatic habitat directly.** These activities could be derived from industrial, residential and recreational actions. These activities could result in the alteration or destruction of riparian habitat. These types of actions and activities could impact both the creek and streams entering the lakes as well as the lakes themselves.
- **Land-based activities which have the capacity to alter aquatic habitat indirectly**. Activities such as the discharge of pollutants as a result of forestry, mining, agriculture and land development incidences could occur. Pollutants of concern include any which change the water quality either temporarily or permanently. Areas which are particularly sensitive will be creeks and rivers flowing into Cowichan and Mesachie lakes where lamprey are spawning and rearing. However, there exists the potential to impact the lakes themselves if pollution is on-going or large-scale. These activities could also include the increased nutrient loading into the water column that could change the water properties leading to eutrophication of the lake.
- **Release of deleterious substances (e.g. hydrocarbons, pollutants and toxins)** through activities such as recreational fishing, boating and house boats. These activities may result in similar impacts to habitat as described in both the direct and indirect land-based activities. It is primarily the lakes and not the creeks or rivers flowing in the lakes which are at greatest risk.
- **Riparian vegetation removal within the defined areas around the lakes and inflowing streams**, or activities that degrade the normal function of riparian area. Riparian vegetation provides food for ammocoetes as detritus as well as creates large and small woody debris which is used as refuge for recently metamorphosed and adult lamprey.
- **Activities that generate significant sediment inputs into adjacent water bodies**. Although turbidity values cannot be provided at this time, significant sediment influx into streams could impair the osmoregulatory capacity of the animal. However, if water flows are maintained within natural variability it is unlikely that the water course would dry up from deposition of sediment.
- **Reduction in prey species due to overfishing**, particularly Cutthroat Trout, through recreational activities and/or as a result of decreased or termination of stocking activities.
- **Removal water from Cowichan Lake via weir operation** resulting in the drying up of spawning and rearing areas. Removal of water from creeks or rivers flowing into Cowichan or Mesachie lakes.
- **Introduction of aquatic invasive species.** The introduction of a foreign species into the lakes may alter the current balance of the predator – prey relationship. It is unknown if Cowichan Lamprey would be able to prey upon other fish species (e.g. Small Mouth Bass) or if they would become prey themselves.

Table 3. Activities likely to destroy critical habitat and associated affected features, functions and attributes.

Activity	Effect Pathway	Function	Feature	Attribute
Excessive nutrient input through groundwater and/or surface flows as the result of non-point sources such as septic seepage.	Eutrophication resulting in algal blooms reducing light penetration, water clarity, changing water chemistry, increased sedimentation rates, altered food web structure	Feeding Egg incubation	Lake habitat Fluvial fans Nest	Water chemistry and clarity Forage availability Excessive siltation Coarseness of substrate
Excessive nutrient input through groundwater and/or surface flows as the result of fertilizer application (commercial or residential)	Eutrophication resulting in algal blooms reducing light penetration, water clarity, changing water chemistry, increased sedimentation rates, altered food web structure	Feeding Egg incubation	Lake habitat Fluvial fans Nest	Water chemistry and clarity Forage availability Excessive siltation Coarseness of substrate
Introduction of invasive species through human activities	Modification of predator/prey relationships	All stages	Lake habitat	Prey availability
Release of deleterious substances such as polycyclic aromatic hydrocarbons (PAH) from petroleum spillage and surface runoff including from recreational activities	PAH do not readily dissolve in water but will bind with organic material and can be deposited in the sediment	Rearing Egg incubation	Fluvial fans	Population abundance due to increased egg and ammocoete mortality
Excessive removal of water	Reduction in water levels in Cowichan Lake and fluvial fan areas where spawning are rearing are occurring. Reduction in water levels in creeks and streams entering into Cowichan and Mesachie lakes.	Spawning Egg incubation Ammocoete rearing	Lake habitat	Survival is not possible in areas which have been de-watered.
Removal of riparian vegetation	Increased siltation, reduction in food, decrease in woody debris for refuge	Feeding Ammocoete rearing Nest building Egg incubation	Fluvial fans Benthic substrate	Successful reproduction and rearing Forage ability Refuge
Overfishing of salmonids (recreational fishing) or reduction in stocking	Reduction in salmon (prey) available for lamprey feeding	Feeding	Lake habitat	Prey availability
Land based activities	Loss of habitat, habitat diversity, increased siltation	Spawning, egg incubation, ammocoete rearing	Stream and nearshore lake habitat including fluvial fans	Ability to spawn and rear eggs and ammocoetes

10 RESIDENCE

The *Species at Risk Act* protects the residences of threatened or endangered species from harm or damage. Residence, as defined by SARA, refers to a dwelling place, such as a den, nest or other similar area or place that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating.

The identification of a residence allows for an additional measure of protection within a critical habitat such as the laying of charges should the residence be destroyed. The residence must support a life cycle function, there must be an element of investment into the creation or modification of the structure and it must be occupied by one or more individuals. The designation of residence is similar to critical habitat, whereby a bounding box method will be used and the features of the residence, as well as frequency and period of use must be described.

Cowichan Lamprey construct nests where eggs are deposited, fertilized, and incubated prior to hatching. Both sexes of lamprey participate in building the nest before spawning. Nest construction involves the excavation of a small depression by vibrating their bodies and carrying individual pebbles short distances using their oral disc. Fertilized eggs remain in the nest until they hatch. Nests support the life-cycle functions of spawning and egg incubation for Cowichan lamprey as such, they are deemed a residence under SARA.

Nesting or spawning locations have not been identified in Cowichan Lake, although one location has been identified in Mesachie Lake. The presence of extremely small ammocoetes in fluvial planes in Cowichan Lake could lead to the assumption of spawning or nesting locations in very close proximity. Cowichan Lamprey spawn from mid-May to late August with a peak in mid-June. The fecundity is unknown. Spawning is followed by death, which is the usual lamprey life history pattern. Ammocoetes live buried in stream or lake sediment until metamorphosing into free-swimming juveniles, they do however move from one location to another.

Based on the description above, the nests that Cowichan lamprey construct either in the streams flowing into either Cowichan or Mesachie lakes or in the lakes themselves should be considered residences under SARA while they are being used for spawning or egg incubation because:

- They are discrete dwelling places that have a form and function similar to that of a nest;
- An investment is made in creating a nests by using their bodies to excavate the depression and their oral disc to carry pebbles for the nest;
- The nests have the functional capacity to support the essential life-cycle processes of spawning and egg incubation;

The nests are occupied by multiple individuals during spawning and egg incubation.

11 KNOWLEDGE GAPS

- To develop a better understanding of habitat use at different life stages.
    a. The current state of knowledge about the species in general and the habitat use is based on limited data.

b. Trapping and electroshocking activities would have to be undertaken at various times of the year in order to increase our understanding of the habitat use, particularly in Cowichan Lake.

c. The identification of spawning locations and habitat in Cowichan Lake is required. This information exists for Mesachie Lake.

d. The role and extent of the riparian component of critical habitat is unclear and needs further delineation. An appropriate analysis should be undertaken to determine the appropriate width of the riparian component of critical habitat.

- To determine food availability for all life history stages and species preference for feeding adults.
- To develop an abundance estimate for Cowichan lamprey. This will require developing reliable methodology and periodic on-going sampling.

12 ACKNOWLEDGEMENTS

The authors wish to acknowledge Dick Beamish for reviewing the paper and providing valuable insight and direction on research activities on Cowichan Lamprey. Special acknowledgement goes to Mr. Gerald Thom who participated in different survey work and who showed immense passion and commitment to the environmental integrity of the Cowichan valley watershed. His enthusiasm, dedication and leadership will be greatly missed.

13 REFERENCES CITED

Beamish, R.J. 1982. *Lampetra macrostoma*, a new species of freshwater parasitic lamprey from the west coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 39: 736-747.

Beamish, R.J. 1985. Freshwater parasitic lamprey on Vancouver Island and a theory of the evolution of the freshwater parasitic and nonparasitic life history types. Pages 123-140 *in* R. E. Foreman, A. Gorbman, J.M. Dodd, and R. Olsson (eds.) Evolutionary biology of primitive fishes. Plenum Press, New York. NATO ASI Series A: Life Sciences: 103

Beamish, R.J. 1986. COSEWIC status report on the Lake Lamprey *Lampetra macrostoma* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 14 pp.

Beamish, R.J. 1998. Update COSEWIC status report on the Cowichan Lake Lamprey *Lampetra macrostoma* in Canada, in COSEWIC assessment and update status report on the Cowichan Lake Lamprey *Lampetra macrostoma* in Canada. Ottawa. 1-9 pp.

Beamish, R. J. and J. Wade. 2008. Critical habitat and the conservation ecology of the freshwater parasitic lamprey, *Lampetra macrostoma*. Canadian Field-Naturalist 122(4): 327-337.

Beamish R.J. and Northcote T.G. 1989. Extinction of a population of anadromous parasitic lamprey, *Lampetra tridentata*, upstream of an impassable dam. Canadian Journal of Fisheries and Aquatic Sciences 46: 420-425.

BC Lake Stewardship Society. 2014. BC Lake Stewardship and Monitoring Program. Cowichan Lake Report 2004-2013. (Accessed September 14, 2016)

Carl, G. C. 1953. Limnobiology of Cowichan Lake, British Columbia. J. Fish. Res. Board Can. 9: 417-449.

COSEWIC. 2000. COSEWIC assessment and update status report on the Cowichan Lake Lamprey *Lampetra macrostoma* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 9 pp.

COSEWIC. 2008. COSEWIC assessment and update status report on the Vancouver Lamprey *Lampetra macrostoma* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 39 pp. (Accessed September 14, 2016)

Cowichan Watershed Board. Cowichan Watershed Board. (Accessed September 14, 2016)

DFO. 2008. National Science Workshop on "Critical Habitat and Recovery Potential Assessment Framework". DFO Can. Sci. Advis. Sec. Proceed. Ser. 2007/057.

Hardisty, M.W., and I.C. Potter, 1971. The Biology of Lampreys. Academic Press, Vol. 1, London. New York, 85-125.

Lawrence M. Page, Héctor Espinosa-Pérez, Lloyd T. Findley, Carter R. Gilbert, Robert N. Lea, Nicholas E. Mandrak, Richard L. Mayden, and Joseph S. Nelson. 2013. Common and Scientific Names of Fishes from the United States, Canada, and Mexico, 7th edition. American Fisheries Society Special Publication #34. 243p.

Potter I.C. 1980. Ecology of larval and metamorphosing lampreys. Canadian Journal of Fisheries and Aquatic Sciences 37: 1641-1657.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin of the Fisheries Research Board of Canada 184.

Stone, J. 2006. Observations on nest characteristics, spawning habitat, and spawning behaviour of Pacific and Western Brook lamprey in a Washington stream. Northwestern Naturalist 87: 225-232.

Taylor, E.B., Harris, L.N., Spice, E.K. and M.F. Docker. 2012. Microsatellite DNA analysis of parapatric lamprey (*Entosphenus* spp.) populations: implications for evolution, taxonomy, and conservation of a Canadian endemic. Canadian Journal of Zoology 90: 291-303.

Vancouver Lamprey Recovery Team. 2007. Recovery Strategy for the Vancouver Lamprey (*Lampetra macrostoma*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa, ix + 21 pp. (Accessed September 14, 2016)

Vessey, M., Tutty, B., Wightman, C., Elliott, J.R., Rutherford, T., and S. Baillie. 2008. Cowichan Weir Start-Up, Operation and Seasonal Protocols.