Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Aquatic Environment

Hydropower Limited Partnership

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APPENDIX 5E
FISH SWIMMING PERFORMANCE

5E.1 INTRODUCTION

Fish swimming performance is generally described using three basic modes: sustained; prolonged; and burst. Sustained swimming is used to achieve relatively slow speeds for long time periods and is generated by aerobic metabolism (Beamish 1978). Burst swimming produces fairly high speeds for short time periods and is fuelled by energy from anaerobic processes (Beamish 1978). Prolonged swimming uses both aerobic and anaerobic energy sources to produce speeds intermediate between sustained and burst (Peake *et al.* 2000). Critical swimming velocity ($Ucrit_x$) has been defined as the maximum velocity a fish can swim against for time x (in minutes). $Ucrit_{60}$ is defined as the highest swimming speed that a fish can maintain indefinitely, or its maximum sustained speed (Beamish 1978).

Critical swimming velocity has been used to infer the ability of fish to swim against velocity in sustained, prolonged or burst modes of swimming. The ability of a fish to maintain position or traverse areas of a river is dependent on several physical and biological factors, including water velocity, mode of swimming (*e.g.*, subcarangiform versus anguilliform), water temperature, and fish length (Katopodis 1993). Studies on Ucrit by Katopodis (1993) demonstrate that for temperate fishes Ucrit can vary among fish species (Table 5E-1).

Classification of the swimming modes of fish is based on the nature of body movements. Fishes found in the study area represent approximate anguilliform and subcarangiform swimming modes (Lindsey 1978). Anguilliform swimming represents undulatory locomotion where the whole length of the body flexes into lateral waves. In comparison, other fishes, like the subcarangiform, are stronger swimmers as they swim by moving mostly the caudal fin and the posterior half of the body.

5E.2 SUBCARANGIFORM

Most average Ucrit values for subcarangiform fish species in the DFO database (all length classes pooled) with satisfactory sample sizes are similar, and have Ucrit values of about 0.55 m/s. Burst, prolonged, and sustained swimming speeds for fish using subcarangiform swimming mode are presented in Figure 5E-1.

5E.3 ANGUILLIFORM

In laboratory conditions, the anguilliform swimmers listed in Table 5E-1 demonstrate a lower aerobic metabolic scope when compared to subcarangiform fishes, and thus are expected to tire more readily. While listed as an anguilliform swimmer by DFO, northern pike are not particularly representative of the undulatory anguilliform swimming mode like that exhibited by eels (Webb 1998). Due to their ambush method of predation, northern pike tend to either move little or, as shown in Figure 5E-2 below, swim slowly or rapidly. Critical swimming velocity for anguilliform fish is lower than that of subcarangiform fish (Table 5E-1). Burst/prolonged and sustained swimming speeds for fish using anguilliform swimming mode are presented in Figure 5E-2.

5E.4 CLASSIFICATION OF WATER VELOCITY

Based on the material presented in Table 5E-1, Figure 5E-1 and Figure 5E-2, water velocity was classified into the following three groupings:

Low (0–0.5 m/s)

Sub-carangiform – all fish greater than 200 mm in length can use sustained swimming. Sub-carangiform fish 200 and 500 mm in length would shift from sustained to prolonged swimming at water velocities of 0.5 and 0.8 m/s, respectively.

Anguilliform – 200 and 500 mm long northern pike will shift from sustained to prolonged/burst swimming at water velocities of 0.1 and 0.2 m/s, respectively.

Medium (0.5–1.5 m/s)

Sub-carangiform – 200 and 500 mm long sub-carangiform fish will shift from prolonged to burst speed at velocities of 0.9 and 1.5 m/s, respectively.

Anguilliform – as water velocities increase from 0.5 to 1.5 m/s, northern pike would shift to more use of burst swimming as opposed to prolonged swimming, and the distance they could swim would decrease.

High (more than 1.5 m/s)

Sub-carangiform – at water velocities greater than 1.5 m/s, sub-carangiform fish of all lengths would employ burst swimming. Endurance would be limited to 10 seconds or less and 200 and 500 mm long fish would be restricted to distances of approximately 0.7 and 4.0 m/s.

Anguilliform – at water velocities greater than 1.5 m/s, northern pike of all lengths would employ burst swimming. As with sub-carangiform fish, endurance would be limited to 10 seconds or less and 200 and 500 mm long fish would be restricted to distances of approximately 0.7 and 4.0 m/s.

5E.5 REFERENCES

5E.5.1 LITERATURE CITED

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Table 5E-1: Mean Ucrit values for select species found in the study area

		Ucrit (m/s)			
Common Name[1]	**Scientific Name**	**Mean**	**Standard Deviation**	**Range**	**n[2]**
Lake whitefish	*Coregonus clupeaformis*	0.545	0.173	0.151-0.905	166
Longnose sucker	*Catostomus catostomus*	0.568	0.212	0.150-1.081	150
Walleye	*Sander vitreus*	0.559	0.214	0.138-0.912	54
White sucker	*Catostomus commersonii*	0.553	0.126	0.326-0.800	20
Yellow perch	*Perca flavescens*	0.434	0.055	0.3130.537	115
Burbot*	*Lota lota*	0.396	0.081	0.201-0.525	52
Northern pike*	*Esox lucius*	0.382	0.150	0.105-0.773	187

Source: Table A11-1 Manitoba Hydro and NCN (2003)
1. Anguilliform; all others subcarangiform.
2. Number of fish measured.

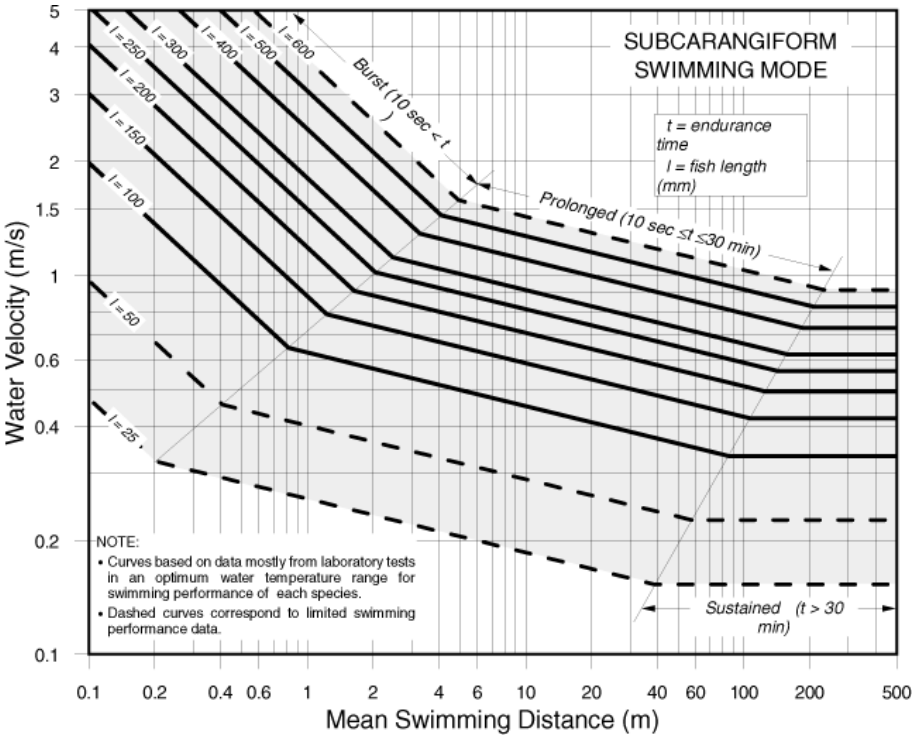

Figure 5E-1: Sustained, prolonged, and burst swimming for fish utilizing sub-carangiform locomotion (after Katopodis 1993)

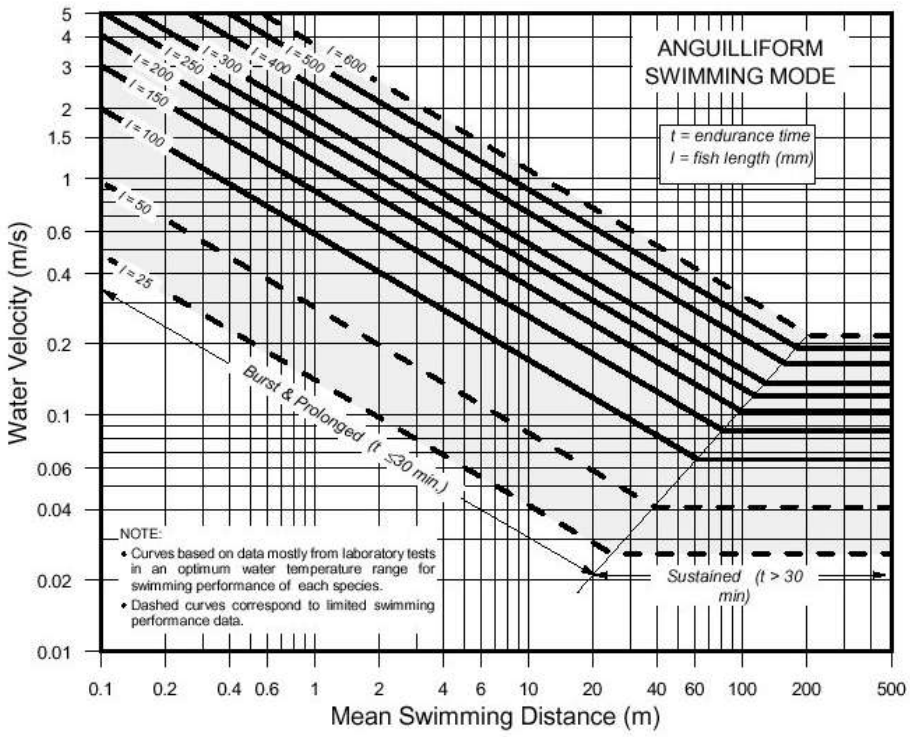

Figure 5E-2: Anguilliform swimming mode water velocities equating to sustained, prolonged, and burst swimming (after Katopodis 1993)