

**OXYGEN CONSUMPTION OF ADULT PACIFIC LAMPREYS  
(*LAMPETRA TRIDENTATA*) IN  
RELATION TO SWIMMING SPEED AND TEMPERATURE**

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**EXTENDED ABSTRACT ONLY – DO NOT CITE**

**Introduction**

Pacific lamprey (*Lampetra tridentata*) populations in the Columbia River Basin (CRB) are believed to be in decline. One factor potentially limiting lamprey production is the amount of energy they expend negotiating upstream passage facilities at dams. Results provided by the National Marine Fishery Service and the University of Idaho suggest that Pacific lampreys have difficulty negotiating the fishways at Bonneville Dam. To compliment this work, we conducted laboratory studies to determine swimming performance and the metabolic costs of activity in Pacific lampreys. We estimated resting and active rates of oxygen consumption ( $\dot{V}O_2$ ) for lampreys swimming at defined speeds at 10, 15, 20, and 23°C. Our results provide a foundation towards estimating metabolic costs associated with swimming for Pacific lampreys.

**Materials and Methods**

Adult Pacific lampreys were collected from the wild and held at the Columbia River Research Laboratory. Oxygen consumption during forced activity was measured on individual lamprey in a Blazka respirometer at four water temperatures (10, 15, 20, and 23  $\forall$ 1°C). Each trial consisted of a progression of steps where water velocity increased from acclimation (0.25 BL·s<sup>-1</sup>) to 0.7 BL·s<sup>-1</sup> and by 10 cm s<sup>-1</sup> each increment thereafter. For each increment, the respirometer was sealed and oxygen concentration measured every 15 s.

Oxygen consumption rate ( $\dot{V}O_2$ ; mg O<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup>) for an individual at each speed was determined using the following equation:  $\dot{V}O_2 = A \times V \times \frac{1}{W}$  where V was the

volume of the respirometer (L); W was the weight of the fish (kg); and A was the amount of oxygen consumed (mg L<sup>-1</sup> O<sub>2</sub>) during the velocity increment as determined by linear regression analysis of the reduction in O<sub>2</sub> over time (t):

$A = b_0 + (t \times b_1)$ . Regression was used to determine the best-fit model for predicting  $\dot{V}O_2$  as a function of swim speed. The effects of temperature and swim speed on oxygen consumption were evaluated using a multivariate ANOVA model predicting oxygen consumption as a function of swim speed, temperature, and interactions between these parameters.

## Results and Discussion

For all temperatures, we documented a similar pattern of increase in  $\dot{V}O_2$  with increasing swim speeds up to approximately 90 cm/s, followed by a decline in  $\dot{V}O_2$  at higher swim speeds. Oxygen consumption increased in a curvilinear fashion with swimming speed at each temperature (Figure 1). Although the relation between swimming speed and  $\dot{V}O_2$  was similar at each temperature,  $\dot{V}O_2$  at each speed was generally higher at 20°C than at the lower temperatures (Table 1). It was difficult to achieve sustained swimming at 23°C and these data are more variable than other temperatures. Oxygen consumption decreased and variability in  $\dot{V}O_2$  tended to be higher at the fastest speeds. Our estimates of active  $\dot{V}O_2$  of adult Pacific lampreys are the first reported for this species and represent estimates of metabolic costs over a range of activity and temperatures. Although active  $\dot{V}O_2$  has been determined for many teleosts, we found reference to only one study that examined this in lampreys. Beamish (1974) reported a mean active  $\dot{V}O_2$  of 475.5 mg O<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup> for adult sea lampreys (*Petromyzon marinus*) swum at 30-40 cm s<sup>-1</sup> at 10°C, which is lower than the mean  $\dot{V}O_2$  we determined for Pacific lampreys under similar conditions. The relatively high  $\dot{V}O_2$  from our lampreys may be partly due to the forced nature of our swim tests. In nature, lampreys use a combination of holdfasting and swimming during their upstream migration to help them conserve energy. Because our data indicate that swimming in lampreys is energetically quite costly, particularly at high water velocities, a greater understanding of lamprey bioenergetics in the wild is necessary before the energetic costs of migration can be evaluated as a factor in the decline of Pacific lampreys in the CRB.

Figure 1.

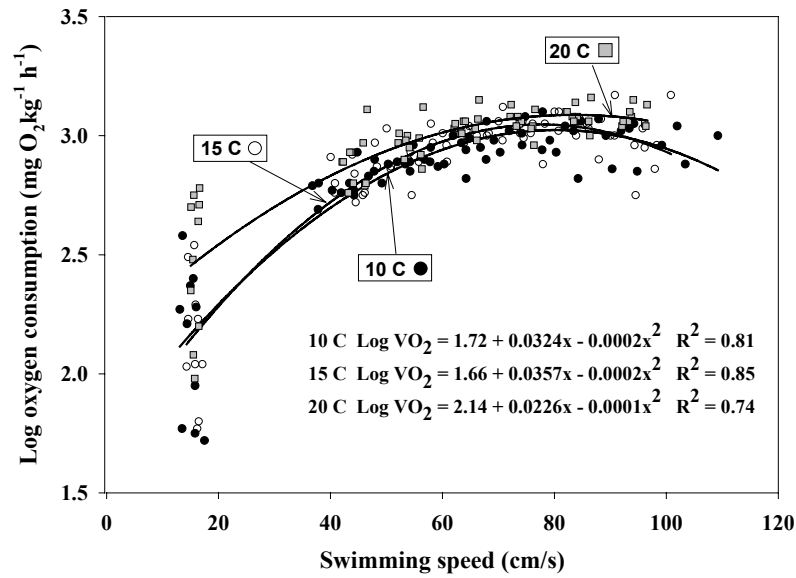


Table 1.

		Mean active oxygen consumption in $\text{mg O}_2 \text{ kg}^{-1} \text{ h}^{-1}$ (SD)						
TEMP (C)	SWIM SPEED (CM/S)							
	Rest	13- 17	40- 45	50-55	60-65	70-75	80-85	90-95
10	34 (6)	166 (34)	634 (46)	783 (29)	866 (54)	1023 (52)	994 (80)	939 (91)
15	66 (9)	164 (31)	681 (52)	794 (69)	966 (40)	1098 (56)	1153 (44)	993 (148)
20	98 (27)	353 (61)	747 (47)	935 (34)	1090 (25)	1181 (36)	1236 (31)	1219 (47)
23	124 (54)	165 (84)	736 (68)	843 (132)	942 (106)	791 (N=1)	NA	NA

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### **References**

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