SWIMMING ENERGETICS AND EPOC IN ADULT SOCKEYE (*Oncorhynchus nerka*) AND COHO (*O. kisutch*) SALMON

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EXTENDED ABSTRACT ONLY – DO NOT CITE

Introduction

In some salmon-bearing streams, water temperatures may fluctuate by more than 13^{o}C in a single day (Mochan and Mrazik, 2000). Thus, when adult salmon return to their natal rivers, they may have to tolerate non-optimal temperatures to reach their spawning grounds (Macdonald *et al.,* 2000), and in some river systems such as the Fraser River, BC, salmon repeatedly swim at velocities that can exceed their maximum aerobic capacity (Hinch & Rand, 1998; Rand & Hinch, 1998). Thus, information on how temperature influences swimming speeds (U_{crit}) and rates of oxygen uptake (Mo_2) provides important integrative information on the fish's physiology, as well as being extremely valuable for fisheries managers who are required to predict the temperature and hydraulic barriers for adult migratory salmon. In this regard and of broader interest, is whether or not different stocks of the same species and in the same river system have evolved different optimal temperatures for U_{crit} and maximum Mo_2 (Mo_{2max}) to exploit different niches within a watershed. The Fraser River is an interesting watershed in which to examine this issue because stocks of salmon in the lower river face relatively short in-river migration distances (~100 km) and colder temperatures. In contrast, stocks of salmon in the upper river face substantially longer in-river migration distances (up to 1,000 km), including particularly challenging sections of white water such as Hell's Gate and Saddle Rock, as well as warmer temperatures.

We are not aware of any study that has examined the swimming energetics of salmon stocks from the same watershed. A few studies have measured U_{crit} in salmonids under field conditions (e.g., Jones *et al*., 1974, Williams et al., 1986; Farrell *et al*., 2002), but only one has measured Mo_2 under field conditions (Lee *et al*., sub). Berst & Simon (1981) suggest that field-based rather than lab-based studies are more likely to reveal any differences among species or stocks, because animal transportation is minimized and natal river water can be used. The effects of temperature on swimming energetics have not been tackled under field conditions. In view of these important data gaps for swimming energetics in adult salmon, the present study took advantage of a newly developed mobile Brett-type respirometer swim tunnel (Lee *et al.* sub.) to perform field-based measurements of U_{crit} and Mo_2 with adult sockeye salmon (*Oncorhynchus nerka*) and adult coho salmon (*O. kisutch*) at various temperatures. Three important questions were addressed: (1) What are the temperature optima for maximum Mo_2 in different Pacific sockeye and coho salmon stocks? (2) How does temperature affect excess post-exercise oxygen consumption (EPOC) and routine Mo_2? (3) Are field-based measurements comparable with more controlled laboratory measurements?

Materials and Methods

Fraser River, B.C. adult salmon were obtained during their in-river migration between May 2000 and September 2001 (Table I).

The majority of salmon were tested on-site in a portable 471.2 L Brett-type respirometer. Water temperatures reflected those that the fish were experiencing at the field location. Some fish were transported to the Cultus Lake Research Facility (Chilliwack, B.C.) and were tested at either their acclimation temperature or at one adjusted no more than 5^{o}C over 5 days. Salmon were swum to exhaustion using a ramp-U_{crit} protocol after a 24-hr habituation period in the tunnel. Two swim trials, ~3 h in duration, were conducted with a 45-min recovery in-between. Oxygen consumption was measured during each swim trial and during the recovery period to assess EPOC. Refer to our website for full details: http://www.sfu.ca/biology/faculty/farrell/swimtunnel/swimtunnel.html

Table 1: Stock information, migration distance and migratory difficulty.

	Stock	Migration Distance	Hydrological Challenge
Long-distance			
Sockeye salmon	Early Stuart (ES)	~1,100 km	Hell's Gate / Saddle Rock
Sockeye salmon	Seton (STN)	~400 km	Hell's Gate / Saddle Rock
Short-distance			
Sockeye salmon	Weaver (WVR)	~100 km	none
Coho salmon	Chehalis (CHE)	~120 km	none

Results and Discussion

Temperature

53% of the variance seen in routine Mo_2 was explained by temperature. Stock-specific temperature optima existed for Mo_{2max} and U_{crit} (Fig. 1).

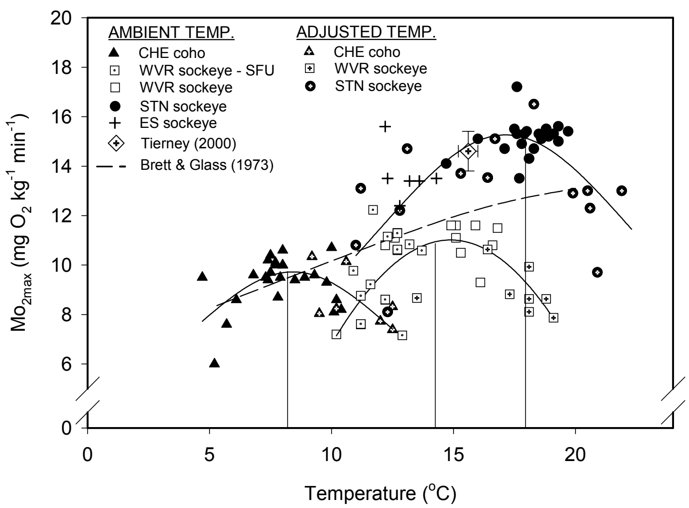

Figure 1: Oxygen uptake at U_{crit} (Mo_{2max}) as a function of temperature for all stocks tested at ambient and adjusted temperatures. Values are shown in relation to Brett & Glass (1973) data on adult sockeye salmon. Distinct peak optimums correspond closely to average ambient water temperature.

EPOC and swimming economy were higher at warmer temperatures (Fig. 2).

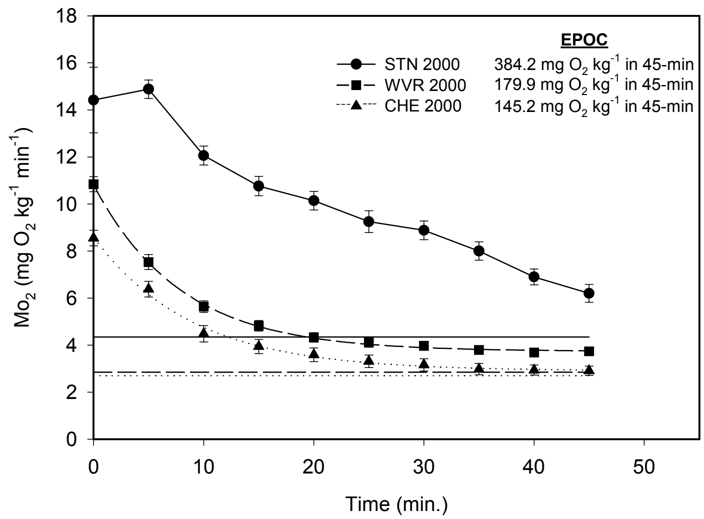

Figure 2: Excess post-exercise oxygen consumption (EPOC) relative to routine Mo_2.

Stocks

At comparable temperatures, Mo_{2max}, U_{crit}, metabolic scope and routine Mo_2 were all higher for long-distance versus short-distance migratory sockeye salmon. The temperature optima in Mo_{2max} for each stock corresponded closely to ambient river temperature.

Field data

Mo_{2max} and U_{crit} field data were equivalent to or better than previously published laboratory data for sockeye and pink salmon (Brett & Glass, 1973; Williams et al., 1986). Results of tests performed at Cultus lake lab were comparable to field data at a comparable temperature. Therefore, we conclude that good quality field testing of salmonid energetics is possible and a short transport with Marinil anaesthetic and ice and a 5-day acclimation period did not impede swimming performance.

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