ENERGY EXPENDITURES DURING REPRODUCTION BY SOCKEYE SALMON (ONCORHYNCHUS NERKA)

by

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(Acc. 23-XII-2002)

Summary
From 1994 to 1996, behaviour and energy use by sockeye salmon spawning in Gluskie Creek, British Columbia, was investigated by a combination of behavioural observation and electromyogram (EMG) telemetry. The spawning life was 7.6 days for males and 10.6 days for females. Both sexes held in pools for a few days, with an average cost of 7.9 kcal/day, before starting to spawn. During spawning, dominant males performed 6 behavioural acts per 10 min, charging being the most frequent followed by quivering, chasing, digging, lateral and posture displays. Spawning females performed 4.4 behavioural acts per 10 min, digging being the most frequent followed by charges and chases. Following egg deposition, females entered a nest guarding phase and, in the latter stages of spawning, males adopted subordinate behaviour. Guarding females and subordinate males performed 1.1 and 1.6 behaviours per 10 min respectively. Lateral and posture displays by males lasted 6.3 s and 11 s respectively but all other behaviours lasted less than 2 seconds. Holding behaviour and posture displays required the most energy in males and holding and digging in females. Dominant males and spawning females expended 23.9 kcal/day whereas guarding females and subordinate males expended 11.0 kcal/day. Frequency of behaviours during active spawning was similar to other populations. Length of spawning life was shorter, however, and total energy expended was less than estimates for other populations based on body constituent analysis. Although EMG telemetry may underestimate total energy expenditure, other recent measures of gross energy expenditure by Stuart River sockeye also indicate that energy available for reproduction was low in this population due to declining average size and low energy reserves in fish arriving at the spawning grounds.

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4) Angela Prince and Pier van Dishoeck provided technical assistance during this project. Funds were provided by NSERC research grants to M. Healey and S. Hinch.
Introduction

The way in which organisms partition available energy among ecophysiological activities such as growth, predator avoidance, and reproduction has important fitness consequences that have been a subject of considerable debate among ecologists (Sibley & Calow, 1986; Roff, 1992). Detailed measures of energy allocation in free living animals are few, however, as are measures of the energetic cost of particular behavioural choices. Knowledge of the energetic cost of behaviour is important to any determination of the trade-offs among behavioural choices that an organism may have to make.

Pacific salmon (*Oncorhynchus* sp.) are ideal subjects for the analysis of energy allocation during reproduction as they are semelparous and do not feed during reproduction. Thus, each individual has only one chance at reproduction and all reproductive activities must be accomplished with energy stores brought to the spawning grounds. Previous research has shown that the gross energy expenditures during upstream migration and spawning of various anadromous salmon species represent 41-80% of total body energy stores (Hendry & Berg, 1999). Published studies suggest that energy use in Pacific salmon from the time fish arrive at the spawning grounds until they die post spawning represents about half of the total energy expenditure from river entry to death. How energy is allocated during migration and spawning can have profound consequences for reproductive success in these fish (Rand & Hinch, 1998; Macdonald *et al.*, 2000). For example, energy expended during migration is not available for courtship and nest defence. Fish that deplete their energy reserves during migration may die *en route* to the spawning grounds or, having arrived, die without spawning (Brett, 1995). The fish must make more subtle allocation choices as well, such as between investing energy in fighting for access to a female or in longevity on the spawning grounds. All such choices have fitness consequences.

In this paper we present an analysis of the energetic cost of reproductive behaviour in sockeye salmon based on electromyogram (EMG) telemetry. EMG telemetry provides a tool for monitoring the activity of individual fish and directly assessing the energetic cost of specific behaviours based on the level of electrical activity in the fish’s muscle tissue (Lucas *et al.*, 1993). We have previously used EMG telemetry to determine the energetic costs of upstream migration in the early Stuart River stock complex of sockeye salmon in the Fraser River, British Columbia, one of the farthest migrating