

## INTERNAL REPORT 153

### FEEDING ECOLOGY AND FOOD HABITS OF LIMNETIC FEEDING FISH

B. D. Doble and A. C. DeLacy  
University of Washington

#### INTRODUCTION

THE IBP is, in part, attempting to quantify the energy flow between trophic levels of the Lake Washington limnetic ecosystem. To this end, estimates of the quantity of food that zooplanktivorous juvenile sockeye salmon (*Oncorhynchus nerka*) eat on a daily basis will provide information on the energy flow between primary and secondary consumer levels, and will relate directly to the population dynamics of both the juvenile sockeye and zooplankton stocks. In addition, information concerning changes in the feeding behavior of juvenile sockeye with changes in the composition and density of available zooplankton prey species will contribute significantly to the limnetic fish modeling effort.

#### TASK OBJECTIVES

Specific objectives were as follows:

- (1) to establish the diel feeding periodicity of juvenile sockeye in the limnetic zone of Lake Washington,
- (2) to establish in situ the rate of gastric evacuation and daily ration of the juvenile sockeye, and
- (3) to determine the relative importance of the dominant zooplankton in Lake Washington to the daily ration of the juvenile sockeye.

The principal parameters to be examined in reference to each of these objectives were size and time of year.

#### DEGREE OF ACCOMPLISHMENT OF TASK OBJECTIVES

The diel feeding periodicity of the juvenile sockeye has been established for all successful sampling dates in 1972 and 1973. Estimates of the instantaneous rate of gastric evacuation and daily ration by size of fish have been completed. An examination of diet and selectivity in feeding by size of fish has been completed.

#### METHODS

The field and laboratory methods are discussed in Doble (1973). Diel sampling was conducted at 2- to 6-hr intervals through 16- to 22-hr periods in August, October, and December 1972, and February 1973. Sampling was attempted in March, April, and June 1972, and April 1973, but

was limitedly successful only in June. The small size of the 1971 year class of sockeye salmon caused sampling to be limited to the limnetic area of highest sockeye density, and therefore, precluded any attempts at comparing areas of different sockeye density or different prey density. Principal sampling gear was a 5.5-m herring trawl fished from the research vessel MV Commando. Echo sounding gear was used to help locate the fish and determine what depths were to be sampled. Throughout most of the sampling period, the juvenile sockeye were layered and a descending-step oblique haul was used to obtain a representative sample of all the fish in the water column. The fish in each haul were brought aboard, anesthetized with tertiary-amyl alcohol to prevent regurgitation, and immediately preserved in 10% formalin. A Miller high-speed plankton sampler was sent down with some of the midwater trawl hauls to secure simultaneous plankton samples. Bathythermograph casts were made.

In the laboratory, the fish in each haul were stratified into length groups and randomly subsampled (sample size 10). Identical length groups were used for all hauls from the same sampling date. Dry weights were obtained on both the stomach contents and bodies of all randomly-selected fish.

Diel patterns in the mean dry weight of stomach contents, excluding empty stomachs, and the proportion of empty stomachs for each length group were used to establish the diel feeding periodicity.

The instantaneous rate of gastric evacuation (percent of dry stomach contents per hour) was estimated for each length group of juvenile sockeye from fish captured in the night hauls. The estimation procedure had assumed that no feeding occurred at night, and that when gastric evacuation (comprising removal of food from the stomach by absorption through the stomach wall and passage to the intestine by peristalsis) was the only function occurring, the rate of change of stomach contents with respect to time was an exponential decrease (Brett and Higgs 1972, Elliott 1972, Tyler 1970).

The daily ration, i.e., the amount of food consumed per day expressed as a percentage of the dry body weight, was estimated from fish captured in both the day and night hauls. The estimation procedure assumed that on the average the rate of food consumption was equal to the absolute value of the rate of gastric evacuation (Davis and Warren 1971, Stauffer 1973, and Tyler 1970). The amount of food consumed per day was estimated by the product of the mean dry weight of stomach contents for 24 hr, the absolute value of the instantaneous rate of gastric evacuation, and the feeding time interval (24 hr).

At the same time that 10 fish were randomly selected for stomach content analysis on a dry weight basis, and additional five were selected for stomach analysis on an enumeration basis. The data were compared with the simultaneously-collected plankton samples to determine selectivity in feeding.

## RESULTS

The diel feeding periodicity of juvenile sockeye in the limnetic zone of Lake Washington was temporally associated in midsummer with rapidly diminishing pre-dusk light intensities. Coincident with this evening feeding period, the young fish underwent a vertical migration towards shallower depths. Although similar pre-dusk vertical migrations were noted on succeeding sampling dates, feeding was not restricted to these periods. In fact, feeding generally commenced at progressively earlier times of the day, and extended over greater portion of the day with advancing time of year. Midday feeding was relatively more important than pre-dusk feeding in winter, and post-dawn feeding was noted only in winter. No distinct differences were noted in feeding activity with respect to size of fish.

Estimates of the instantaneous rate of gastric evacuation (Table 1) indicated a general decrease in the rate with advancing time of year. The estimates also indicated a general decrease in the rate with increasing size of fish. Hypothetical curves of rate change, linear and exponential, were fitted to the estimates by least squares (Figure 1 - example is for June). The slopes of the fitted curves were negative for all cases except December fish, and were significantly different from zero for June and October fish.

The amount of food consumed per day generally increased with increasing size of fish; however, on a relative basis, i.e., expressed as a percentage of the body weight, it decreased. Food consumption reached a peak in October.

Definite differences were noted in prey species consumption with respect to size of fish in June and August. Size of prey species consumed generally increased with increasing size of fish. The smaller fish primarily consumed *Cyclops bicuspidatus* and *Diaptomus ashlandi* while the larger fish consumed *Diaphanosom leuchtenbergianum* and *Epischura Nevadensis*. No distinct differences were noted on succeeding sampling; *E. nevadensis* generally formed the bulk of the stomach contents.

## DATA STORAGE AND AVAILABILITY

Pertinent data related to the field trips, hauls, and catches were recorded on Fisheries Research Institute coding form S130.1 (IBP Tow-Net and Mid-water Trawl Data Form). The length and weight data from the juvenile sockeye were recorded on form S130.2 (IBP Fish Length and Weight Data Form). The dry weight data were recorded on form S130.3 (IBP Sockeye Salmon Rate of Gastric Evacuation and Daily Ration Data Form). The data, after being punched and verified, were stored on cards. They are presently being prepared for input to the IBP data bank.

## REFERENCES

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Table 1. Estimates of the instantaneous rate of gastric evacuation (R), with 26 confidence intervals, and daily ration (D) for the various length groups of juvenile sockeye salmon captured on each sampling date. (R is percent of dry stomach contents per hour, and D is percent of dry body weight per day).

Sampling date	Length group (mm)	Temperature range (°C)	R	
				D
12 June 1972	≤44	8.0-15.5	40.5 ± 24.6	
	45-54		46.6 ± 20.5	
	55-64		32.9 ± 17.0	
	≥65		17.9 ± 13.4	
22-23 August 1972	≤64	7.0-8.0	26.7 ± 11.6	
	65-74		15.9 ± 11.2	
	75-84		19.1 ± 11.5	
	85-94		23.2 ± 7.2	
	≥95		18.2 ± 8.4	
25-26 October 1972	≤74	8.0-12.0	16.2 ± 5.7	
	75-84		14.0 ± 8.4	
	85-94		19.9 ± 6.3	
	95-104		17.9 ± 7.2	
	105-114		11.8 ± 6.6	
14-15 December 1972	≥115	6.5-7.0	8.5 ± 4.3	
	≤84		9.3 ± 10.3	
	85-94		3.4 ± 4.0	
	95-104		4.1 ± 8.3	
	105-114		3.4 ± 5.7	
	115-124		1.7 ± 8.0	
12-13 February 1972	≥125	4.5-5.0	10.8 ± 6.7	
	≤84		10.9 ± 12.9	
	85-94		3.3 ± 11.1	
	95-104		4.2 ± 8.7	
	105-114		5.6 ± 6.4	
	115-124		2.0 ± 9.6	
	≥125	8.2 ± 9.9		

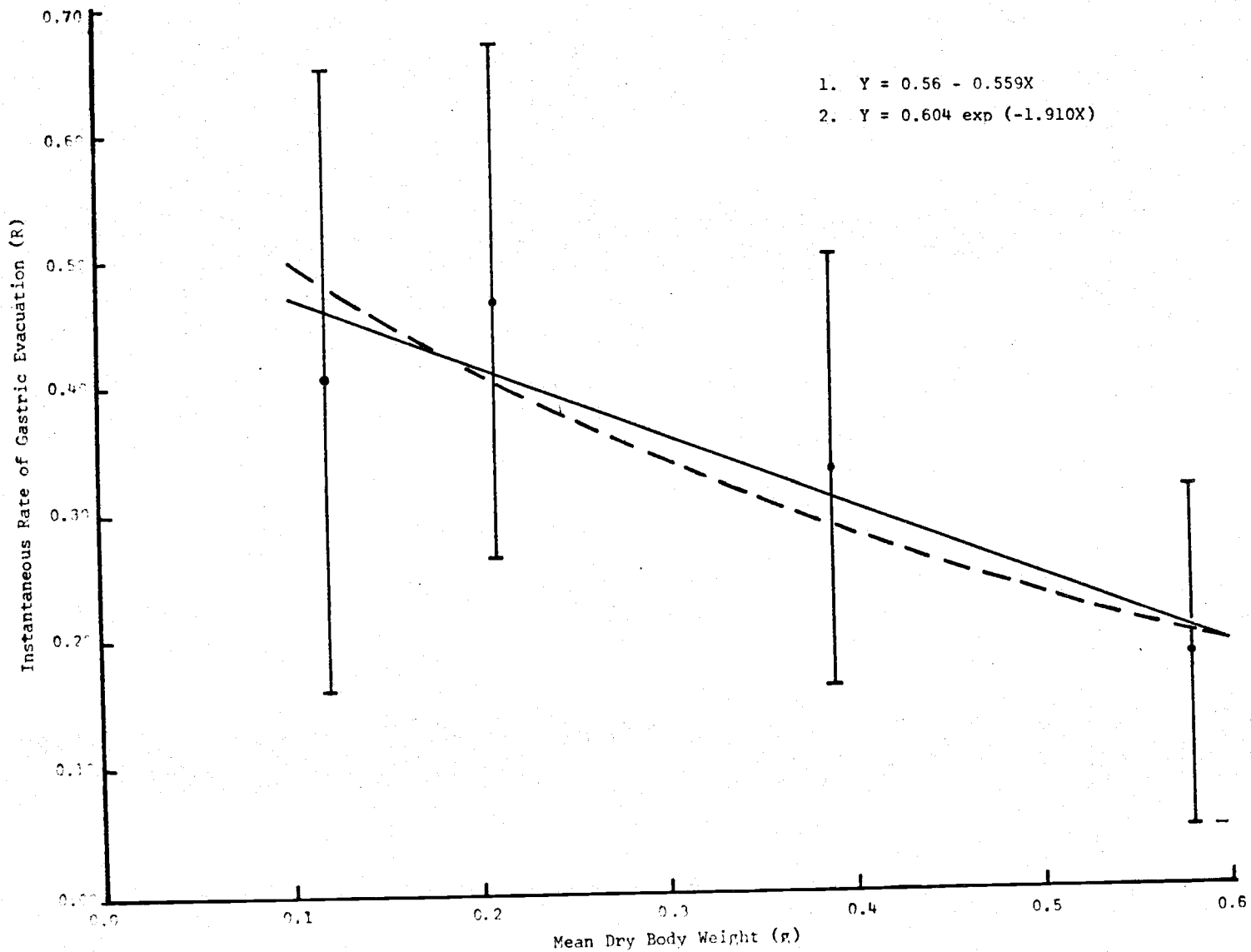


Figure 1. Estimates of the instantaneous rate of gastric evacuation, with  $2\sigma$  confidence intervals, for different sizes (mean dry body weight of each length group) of juvenile sockeye salmon captured on June 12, 1972. Superimposed are hypothetical curves of rate change from a linear (—) and an exponential (- - -) model fitted by least squares.