Juvenile (zooplankton) diet retention by the adult age class of yellow perch (*Perca flavescens*) in Sunfish Lake, Waterloo, Ontario.

by
Victor Y. Nishi

Submitted to the Department of Biology
Queen's University,
Kingston, Ontario.

April 1982

In partial fulfillment of
the requirements for the degree
of Bachelor of Science.

ABSTRACT

The diet and growth of yellow perch (*Perca flavescens*) in Sunfish Lake, Ontario, was examined during the summers of 1980 and 1981. Zooplankton were the dominant component of the diet for all age classes and in all seasons, comprising 40-80% (x = 62.9%) of all stomach contents. Within this zooplankton diet, perch selected only the larger *Daphnia* spp. although these species were not the most common, nor were these sizes the most abundant. These data indicate that yellow perch in Sunfish Lake retained a juvenile diet in the adult age classes, a result that contrasts with other published information on perch feeding ecology. The few studies which have documented a predominantly zooplankton diet in adult perch also indicated a reduced growth. However, overall growth of perch in Sunfish Lake was greater than that reported in the literature, due primarily to high growth rates in first and second year class individuals. Although the abundance of Cladocera and Copepods varied between sample sites, average abundance was as high as 1.4 x 10 *Daphnia* per m in the July sample. This high density of zooplankton was responsible, at least in part, for the observed retention of a juvenile (zooplankton) diet.

ACKNOWLEDGEMENTS

I would like to thank the following people, whose assistance and support were greatly appreciated:

Dr. S.R. Brown, my supervisor, who provided guidance and assistance whenever I could catch up to him.

Mr. and Mrs. Jack Hutchison for their kindness and hospitality in welcoming me into their home during sampling trips to Sunfish Lake.

Dr. Keast, for providing sampling equipment, lab space and helpful suggestions along the way.

John Eadie, Jim Complak, Lois Deacon, and Francois Chapleau for their support (?) and assistance every step of the way (Co-authorship denied even if deserved).

Joe Brown, Mark Abrahams, Sandi Orsetti, and Alastair Mathers for words of wisdom.

Peter Leavitt and John Eadie for helpful criticism during manuscript preparations.

Dave Allan for assisting in the field and asking nothing in return.

Renee Robinson - biology friend - for assistance in the field, etc.

TABLE OF CONTENTS

	Page
Abstract	ii
Acknowledgements	iii
List of Figures and Tables	v
Introduction	1
Methods and Materials	6
Study Lake	6
Sampling Sites	10
Fish Collection	11
Zooplankton Collection	14
Stomach Analysis	15
Results	17
Perch Feeding	17
Zooplankton	22
Fish Growth	28
Discussion	35
Conclusion	48
References	50
Appendices	54
Fish lengths, weights, ages and diets	
Zooplankton population abundance data	

LIST OF FIGURES AND TABLES

		Page
Figure 1.	Location map of Sunfish Lake	7
2.	Hydrographic map of Sunfish Lake showing zooplankton and fish sampling sites (Wynne-Edwards 1981)	9
3.	Yellow perch diet categorized with respect to age class and sampling date	19
4.	Size distribution of _Daphnia_ spp. consumed	21
5.	Population abundance of _D. schodleri_ (a) and _D. retrocurva_ (b) at various sampling sites on fish collection dates	23
6.	Population abundance of _D. leuchtenbergiana_ (a) and Copepoda (b) at various sampling sites on fish collection dates	24
7.	Averaged abundance of all sites for Copepoda Cladocera, and _Bosmina_ populations on fish collection dates	25
8.	Size distribution of _Daphnia_ spp. in Sunfish Lake	26
9.	Size distribution of _Daphnia_ spp. consumed by yellow perch	27
10.	Size distribution of yellow perch collected from Sunfish Lake. Year, class limits are also indicated	29
11.	Length - age plot for Sunfish Lake yellow perch	31
12.	Instantaneous rate of growth for Sunfish Lake yellow perch	32
13.	Regression of log weight on log length for yellow perch in Sunfish Lake.	33
14.	Comparison of Sunfish Lake _Daphnia_ spp. population abundance to data collected from other regional lakes	37
15.	Comparison of Sunfish Lake length age plot to data collected from other regional lakes	38

Page

Figure 16. Comparison of Sunfish Lake yellow perch instantaneous rate of growth to data collected from other regional lakes. 40

Table 1 Morphometric data for Sunfish Lake 8

2 Comparative feeding data - 1980-1981 18

INTRODUCTION

The efficient acquisition of food is essential to the survival of any individual in a competitive environment. Current theory presumes that morphological features of an individual are modified by natural selection to allow more efficient use of potential resources, thus giving that individual a competitive advantage over other individuals and a greater probability of survival (Ricklefs 1979). Acting contrary to specialization is the need to remain flexible enough to adapt to changing conditions in the enviroment. The feeding strategy that a species possesses is the product of these two factors.

Conditions within a temperate lake are highly variable over the course of a single year. Population peaks of planktonic or benthic organisms can last from several days to several months (Wetzel 1975). As a result, fish that feed upon these organisms tend to adopt a strategy flexible enough to conform to these population peaks, yet specialized enough to compete successfully with other species.

The diet of the yellow perch (Perca flavescens) has been intensively studied, due to its commercial and recreational importance. These studies have generally indicated a diet of zooplankton, immature insects, larger invertebrates and fish. This diet tends to shift from smaller to larger organisms with increasing perch size. Clemens et al. (1924) found that Lake Nipigon perch less than 40 mm fed almost exclusively on plankton. In fish 40-80 mm in length, insects and fish became increasingly important and above 80 mm plankton consumption became negligible. Ewers (1933) reported 94.3% of the food of Lake Erie perch between 14-79 mm consisted of copepods and cladocerans. Perch collected in seven northern Wisconsin lakes showed planktivory only during their first year, after which they switched to a diet of insects. Occassional piscivory began early in life but did not become a major food resource until 180 mm or greater (Couey 1935).

More recently, Clady (1974) observed similar shifts in yellow perch collected from two unproductive lakes in northern Michigan. Brown (1977) also observed these shifts during an examination of feeding and growth relationships in three southeastern Ontario lakes and in the Bay of Quinte, Lake Ontario. Keast (1977) presented perhaps the most in depth analysis of yellow perch feeding. His results support the idea of a shifting diet with these shifts occuring at 40-60 mm and 140-160 mm in length.

According to Keast (1977) these dietary shifts are generally the result of changing energetic requirements of the fish. Energetic benefits obtained through food consumption must satisfy maintenance requirements (basal metabolic requirements, digestion, locomotion, etc.) as well as costs of foraging and handling of food (Brett and Groves 1979). Once these requirements have been satisfied, energetic surplus can be channelled into one or both of growth and reproduction. As the fish grows, the cost of maintenance increases (Phillips 1966). This increasing cost serves to limit the minimum size of prey which can be 'economically' consumed. The maximum prey size for non-filter feeding fish is limited by the size of the predator's mouth (Keast and Webb 1966). Consumption of prey much larger that the size of the mouth increases handling costs above a critical level beyond which the consumption of the prey ceases to represent a net energetic gain. These two factors - increasing maintenance costs and mouth size - serves to produce an optimal foraging strategy which favours the shifting of selected prey size with increasing predator size.

There have been a few cases in the literature in which yellow perch have retained a planktonic diet, but these have been generally associated with less than average growth. Langford and Martin (1940) found Daphnia to be the dominant food item in the stomachs of all age classes in Lake Mendota, Wisconsin. This diet was associated with less than average growth based on comparative data collected by Keast (1977). Erschmeyer (1937) examined the diets of populations of stunted perch in the Pigeon River pothole lakes of Michigan. He found small items to predominate in their stomachs. This suggested low availability of intermediate sized food items. The absence of this prey resource was thought to have been responsible for reduced growth and periodic 'die offs' of selective year classes.

In addition to these age correlated or length correlated shifts, the diet of yellow perch tend to experience wide seasonal fuctuations. These are generally correlated to seasonal fluctuations in prey abundances (keast 1977, Brown 1977).

Wynne-Edwards (1981) conducted a study of the benthic resource base utilization by the fish population of Sunfish Lake. Her results on yellow perch indicated a rather high degree of planktivory in the adult age classes. The retention of a juvenile diet appeared to be a possibility. Unfortunately, her sample sizes were too small to make any definite statements regarding perch diet and growth. Also, quantitative data was unavailable on zoolankton abundances, making it impossible to evaluate the resource base on which perch may be feeding.

My study investigated yellow perch feeding and growth in Sunfish Lake in greater detail. A second sampling season was added to Wynne-Edwards' 1980 collection. In addition, quantitative zooplankton samples were collected. These results showed a clear retention of a planktivorous diet in the adult population of yellow perch. This apparantly uncommon diet may, in part, be due to the rather high concentrations of zooplankton which appear to be present in the lake.

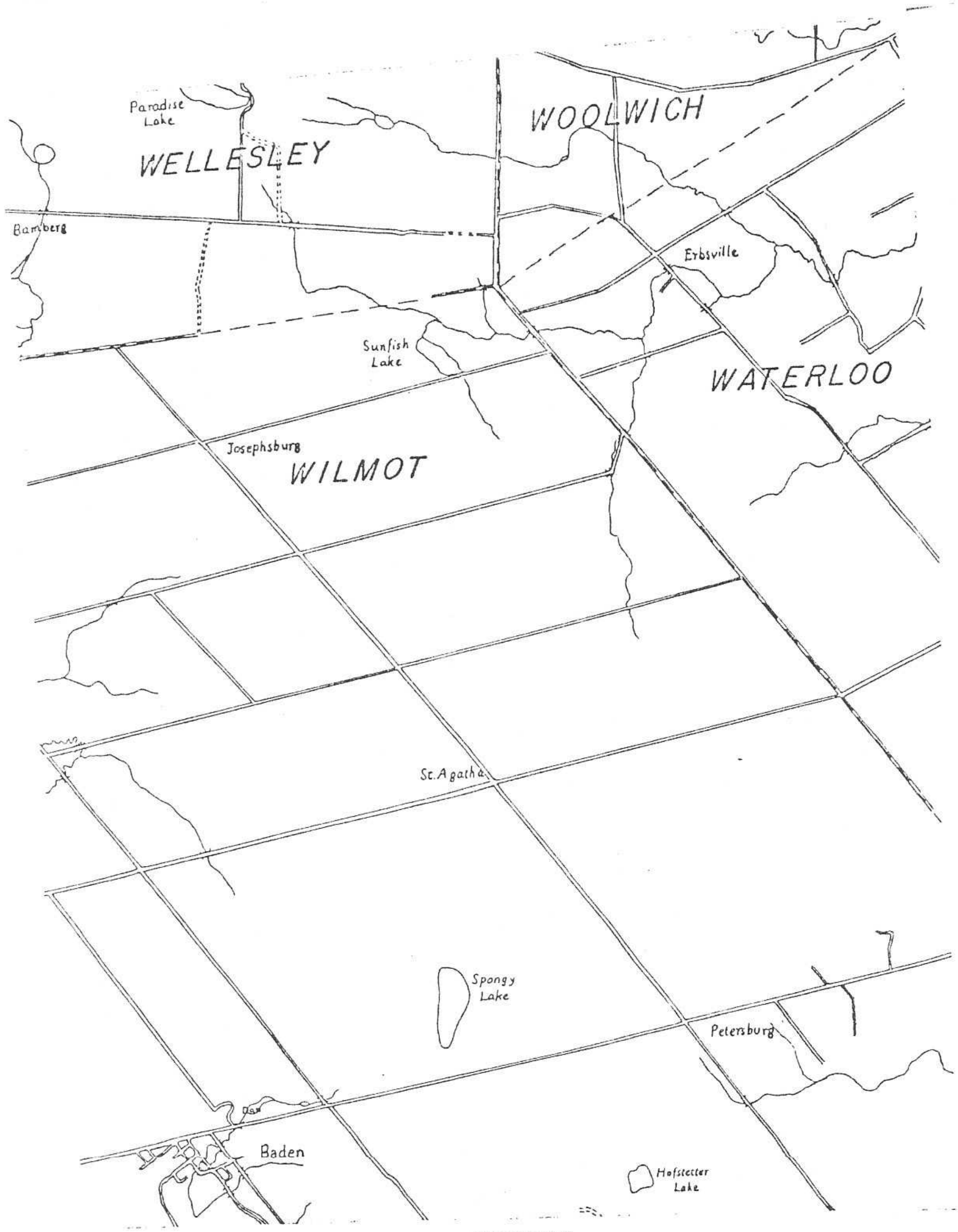
METHODS & MATERIALS

STUDY LAKE

Sunfish Lake is situated in Southern Ontario, N 43 28′ 4″ W 80 38′, in Wilmot Township (figure 1). With Spongy and Hofstetter lakes, it forms a series of kettle lakes over a bedrock of shale, salt and gypsum (Duthie and Carter 1970).

The lake is deep in relation to its surface area (table 1). The relative depth (maximum depth expressed as a percent of the mean diameter), and the volume development are high, indicating the pronounced concavity of the lake basin (Wetzel and Likens 1979). The lake, therefore, possesses a rather limited littoral zone with the exception of the south-east end of the lake (figure 2).

According to Sreenivasa and Duthie (1973) the lake became eutrophic 850 years B.P. and biogenically meromictic 140 years B.P. This was determined through analysis of the diatom stratigraphy in the sediments. Several small temporary inlets feed the lake. In addition, the presence of subsurface springs have been reported by local residents



REFERENCE

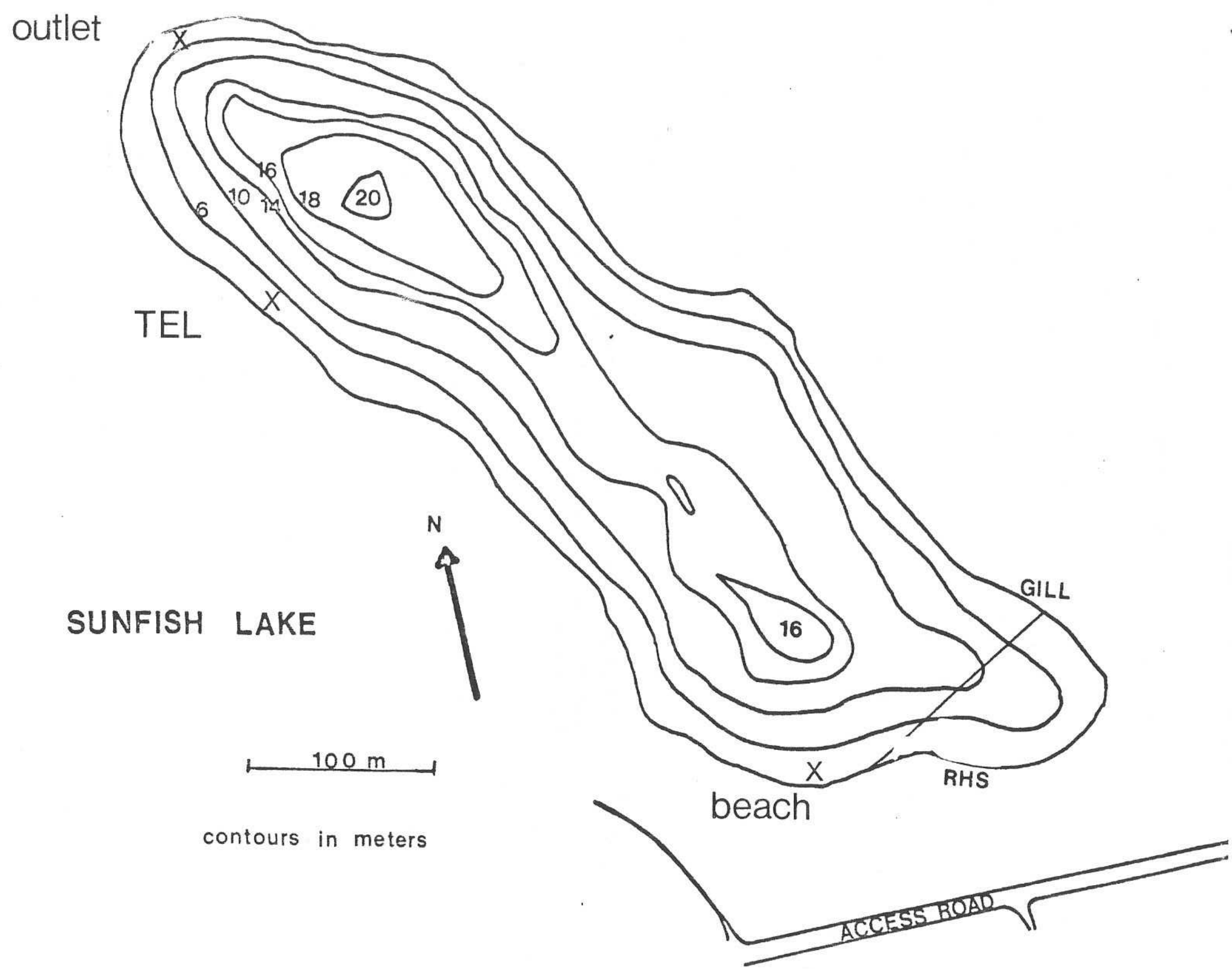
Township boundary ----
Road
Dry weather road
Bridge

1 mile or 1684 meters

TABLE: 1

Morphometric Data for Sunfish Lake
(from Duthie and Carter, 1970).

Surface Area	8.3 ha
Maximum Length	577 m
Maximum Width	189 m
Maximum Depth	20.0 m
Mean Depth	10.4 m
Volume Dev. Ratio	1.56
Relative Depth	6.15%


outlet
TEL
6
10
14
16
18
20
16
GILL
RHS
beach
ACCESS ROAD
N
SUNFISH LAKE
100 m
contours in meters

(Duthie and Carter 1970). Only one outlet stream exists and forms a tributary to Laurel Creek (Bhajan 1970).

Chara is the only abundant macrophyte occuring in the littoral zone, often growing into dense mats up to 75 cm deep. Littoral sediments are characterized by a layer of calcarious marl underlain by a highly reduced organic ooze (Wynne-Edwards 1981).

SAMPLING SITES

FISH: Two sites were selected for seine netting: Outlet and Beach (figure 2). These were the only two sites on the lake where the littoral zone was wide enough and clear enough to allow for effective seining. The Outlet site littoral zone extended out approximately eight metres and supported moderate *Chara* growth (depth of *Chara* > 40 cm). The Beach site littoral zone extended out eight to twelve metres and was much longer. The bottom sediments consisted of coarse grained marl and gastropod shells, and supported only patches of *Chara*.

Alternate sites were selected for setting gill nets: RHS and TEL (figure 2). The RHS gillnet blocked access to the inlet and littoral zone of the south-east end of the lake. The water at the point of net setting was rarely deeper than three metres, leaving less than one metre of water between the bottom of the net and the lake bed. TEL was a stretch of rather limited littoral zone covered in dense Chara and littered with stumps and fallen branches.

ZOOPLANKTON: May samples were collected in a vertical transect situated over the deepest part of the lake. Sampling in July was restricted to the two littoral zone fish collection sites described above. Both the littoral zone sites and the pelagic vertical transect were sampled in September. Yellow perch have been shown to spend most of their time in the pelagic zone of the lake, migrating into the littoral zone at dawn and at dusk (Hasler and Bardach 1949) presumably to feed. Therefore, both littoral and pelagic samples were required to investigate the yellow perch's entire habitat range.

FISH COLLECTION

Sampling techniques were designed to approximate those employed by Wynne-Edwards (1981) in order to minimize possible sources of error resulting from sampling inconsistencies. Fish sampling occurred between May 21-28, July 6-12, and September 5-12. These dates were selected to correspond with the onset of growth and feeding in May, the period of most rapid growth in both fish and macrophytes in July, and final growth prior to overwintering in September. Collection during these three periods should give an accurate picture of fish feeding and growth (Keast 1977).

Replicate seine net sweeps were made at the Outlet and Beach sites between 0600-0900 and 2000-2200 hours to coincide with feeding activity within the littoral zone (Hasler and Bardach 1949). The nylon seine net used was 15 m long by 2 m deep with a collection bag mesh of 0.5 cm. This would be small enough to retain most young-of-the-year fish.

The monofilament gill net was approximately 100 m long. This was composed of four 25 m panels of varying mesh sizes (2,3,4,and 5 cms). Portions of the net were set parallel to the shore in order to capture fish migrating into the littoral zone. Other portions were set perpendicular to the shore to capture fish swimming within the littoral zone. The net was cleared every 24 hours.

Captured fish were preserved in 10% formalin buffered