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ABSTRACT

Studies on growth, food, sexual dimorphism, maturity, fecundity, and proximate analysis were carried out on 432 mooneye, Hiodon tergisus (Le Sueur) in two different locations in the Ottawa River, near Ottawa and Hull during 1976 and 1977.

Scales, after certification with otoliths and vertebrae, were used to age mooneye. Increase in length and weight at specific ages was similar in 1976 and 1977 for the lower Ottawa River. The same holds true for upper Ottawa River mooneye. Significant differences ( $P \leq .05$ ) were found when weight-length data were compared from both locations. Weight-length relationships for 1977 were as follows:

lower Ottawa River:  $\log W = 3.0945 \log L - 2.1645$

upper Ottawa River:  $\log W = 2.9572 \log L - 1.9235$

Relative growth was similar for both locations for fish ages three to 12. In the lower river mooneye grew 32.8 percent in weight during their first year while during their second year they grew 86 percent.

Condition factors of lower river mooneye varied significantly ( $P \leq .05$ ) from those in the upper river at ages four, five, and six. Age class six had a condition factor of 938.33 in the lower river and 1014.57 in the upper river.

Mooneye ate aquatic larvae and nymphs, emergent adults, and terrestrial insects. The most important food items were Ephemeroptera, Tricoptera, Diptera, and Coleoptera. The organisms consumed were dependent on their availability in the field.

Sexual dimorphism was present in adults; mature males

possessed a fleshy lobe on the anal fin adjacent to which was a depression on the body. These features were not present in females.

Female mooneye mature at four years in both locations. Males mature at the same age in the upper river and at age three in the lower river. The sex ratio was 2.2:1 and 3.4:1 in favor of females to males in the lower and upper river respectively.

The oldest fish caught in the lower river was eight years old. In the upper river one 13 year old female and an 11 year old male were caught.

Gonadosomatic Indices increased with age during the summer months. In the lower river the GSI's peaked in May and June. Spawning occurred from mid-May to mid-June in the lower river when temperatures were 10-14°C.

Egg diameter was 2.24 mm for ripe females. Total fecundity ranged from 6,000 to 9,000 eggs per ripe female.

Proximate analysis of adult mooneye muscle revealed protein, fat, and moisture content to be approximately 19-20, 1-2, and 76-78 percent respectively and the values were not significantly different for males and females.

## RESUME

Des études de croissance, d'alimentation, de dimorphisme sexuel, de fécondité, et une analyse du contenu d'eau, de gras, et de protéine dans les muscles, furent faites sur 432 laquaiches argentées, Hiodon tergisus (Le Sueur), à deux différents emplacements de la rivière des Outaouais, près d'Ottawa et Hull en 1976 et 1977.

Après confirmation avec les otolithes et les vertèbres, les écailles furent utilisées pour déterminer l'âge des laquaiches. Un accroissement en longueur et en poids à des âges spécifiques fut semblable durant 1976 et 1977 en aval de la rivière des Outaouais. Il en est de même pour l'amont. Des différences significative ( $P \leq .05$ ) furent observées dans les données poids-longueur pour 1977 furent:

$$\text{aval: } \log W = 3.0945 \log L - 2.1645$$

$$\text{amont: } \log W = 2.9572 \log L - 1.9235$$

La croissance relative fut semblable aux deux emplacements pour les poissons âgés de trois à 12 ans. L'augmentation en poids fut de 32.8 pourcent pendant la première année et de 86 pourcent pendant la deuxième année chez les laquaiches provenant de l'aval de la rivière.

Les coefficients de condition physique des laquaiches de l'aval de la rivière ont varié de manière significative ( $P \leq .05$ ) de ceux de l'amont aux âges quatre, cinq, et six. Les laquaiches de six ans avaient un coefficient de condition physique de 938.33 en aval de la rivière et de 1014.57 en amont.

Les laquaiches ont mangé des larves aquatiques et des nymphes, des adultes fraîchement éclos, et des insectes terrestres. La majeure partie de leur diète était composée d'éphéméroptères, de tricoptères,

de diptères et de coléoptères. Les organismes consommés dépendaient de leur disponibilité dans l'environnement.

Les adultes présentaient un dimorphisme sexuel. Les mâles adultes possédaient un lobe charnu sur la nageoire anale au dessus de laquelle on peut voir une dépression; ces traits n'étaient pas présent chez les femelles.

Les laquaiches femelles ont atteint l'âge adulte à quatre ans aux deux localités. Les mâles ont mûri au même âge en amont de la rivière et à l'âge de trois ans en aval. La proportion des sexes était 2.2:1 et 3.4:1 en faveur des femelles en aval et en amont de la rivière, respectivement.

Le plus vieux poisson pêché en aval de la rivière était âgé de huit ans. En amont, une femelle de 13 ans et un mâle de onze ans furent pris.

Les indices gonadosomatiques ont augmenté avec l'âge pendant la période estivale. En aval de la rivière, les IGS on atteint leur maximum en mai et juin. La fraie eut lieu de la mi-mai à la mi-juin en aval de la rivière quand les températures ont atteint 10-14°C.

Les femelles prêtes à pondre avaient des oeufs de 2.24 mm de diamètre. La fécondité totale variait de 6,000 à 9,000 oeufs par femelle mûre.

L'analyse du contenu de protéines, de gras et d'eau dans le tissu musculaire a révélé des valeurs de 19-20, 1-2 et 76-78 pourcent, respectivement. Il n'y avait pas de différence significative entre les mâles et les femelles.

## INTRODUCTION

This study was undertaken to determine the growth patterns, food, maturity, and fecundity of mooneye, (Hiodon tergisus) (Le Sueur) in two areas of the Ottawa River. Also, it attempts to ascertain whether this fish could be a good game fish; to this end proximate analysis was done on mooneye muscle.

Mooneye are restricted to North America. They are found in James Bay, Northwestern Quebec, the Ottawa River to Lake Champlain and the St. Lawrence River, through the Great Lakes and as far west as Alberta (Scott, 1967; Scott and Crossman, 1973; Roberts, 1974). Its southerly range extends from New York and Pennsylvania to Arkansas and Oklahoma and northward through Kansas and North Dakota to Manitoba, Saskatchewan, and Alberta.

Records of mooneye caught in the Great Lakes in the early 1900's were erroneous (Van Oosten, 1961). The name mooneye was mistakenly applied to goldeye, gizzard shad, alewife, and even some chubs and ciscoes by commercial and sport fishermen.

Mooneye are not of commercial importance as are the goldeye, thus not very much is known about their ecology and growth. Glen (1975, 1976) is currently studying mooneye in the Assiniboine River, Manitoba. His studies are centered on fecundity, growth, and seasonal diets of mooneye. The only other extensive research on mooneye was undertaken by Johnson in Lakes St. Clair and Erie, in 1951. He undertook an ecological investigation which encompassed growth, food, histological studies of the gonads, and parasitology. There is a lack of knowledge pertaining to mooneye in the eastern part of its range.

## MATERIALS AND METHODS

## Description of Study Area

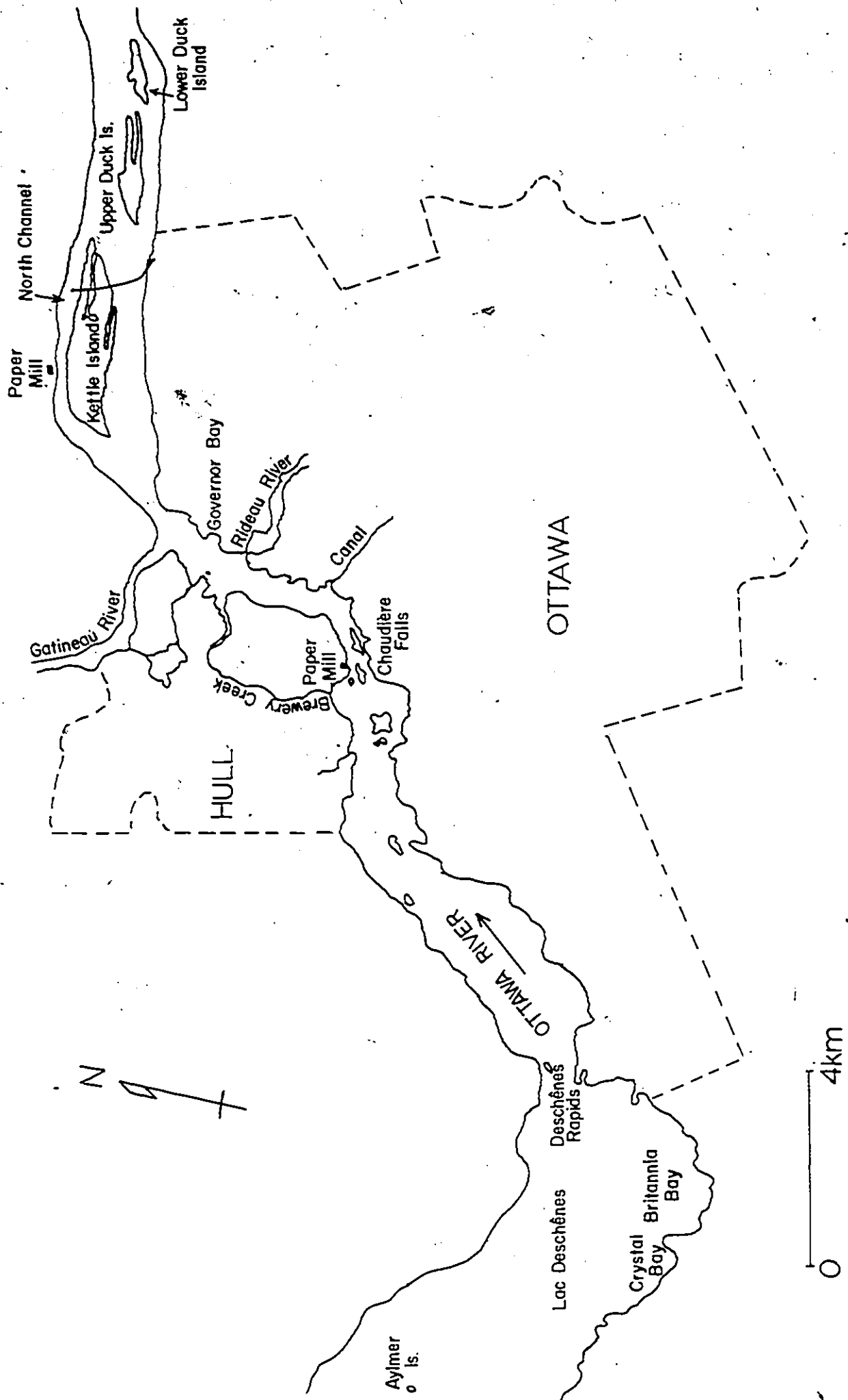
The Ottawa River extends 1,113 km from Lake Temiscamingue to the St. Lawrence River with an approximate drainage area of 145,000 sq. km. Two areas of the Ottawa River, near Ottawa-Hull were considered for this study, namely the lower and upper river.

The lower Ottawa River comprises the area from the Chaudière Falls ( $75^{\circ}44'$  longitude west,  $45^{\circ}25'$  latitude north) to the Lower Duck Island ( $75^{\circ}35'$  longitude west,  $45^{\circ}28'$  latitude north) and includes Brewery Creek, Governor Bay, Kettle Island, Upper Duck Island, and Lower Duck Island (Fig. 1). The current is swift and the shoreline drop off is very steep. Depth varies from 6 to 16 m in the main channels, however, in Governor Bay, Brewery Creek, Kettle Island Bay, and the north side of Lower Duck Island the depth is 3 m or less. The substrate of the main channels is composed mostly of clay, sand, and woodchips, while in the bays, soft mud bottoms are found.

The area from Aylmer Island ( $75^{\circ}53'$  longitude west,  $45^{\circ}24'$  latitude north) to the Deschênes Rapids ( $75^{\circ}48'$  longitude west,  $45^{\circ}23'$  latitude north) is designated the upper Ottawa River. Specific sampling locations are Aylmer Island, Crystal Bay, Britannia Bay, and the tip of the Deschênes Rapids (Fig. 1). Crystal Bay and Britannia Bay have gentle sloping shorelines, a sand and mud substrate, slow currents, and a depth range from 1-9 m. Aylmer Island and the area immediately before the Deschênes Rapids have steep shorelines, a rock bottom, swift currents and a depth of approximately 9-13 m.

3a

Fig. 1. Sampling locations situated in the lower and upper Ottawa River during 1976 and 1977.



The physical and chemical parameters of the Ottawa River water at various locations have been analyzed for over ten years (Mackie, 1971; Smith, 1974; Hanson and Qadri, 1979). These are presented in Table 1.

#### Fishing Gear and Catch

Mooneye were caught by gill nets from April to October in the lower Ottawa River and in July and August in the upper Ottawa River during 1976. In 1977, by means of both gill nets and angling, mooneye were caught from May through August in the lower Ottawa River and from June through September in the upper Ottawa River. In 1976 and 1977 there were 108 and 89 fish caught in the lower Ottawa River respectively. In the upper Ottawa River, 47 and 188 fish were caught respectively. Of the 188 fish captured in the upper Ottawa River in 1977, 85 were caught by angling just above the Deschênes Rapids. Remaining fish were caught by means of gill nets. The number of fish caught on a monthly basis is found in the table below.

Table 2. The number of fish caught in each month in the lower and upper Ottawa River in 1976 and 1977.

	April	May	June	July	August	Sept.	Oct.
lower Ottawa River 1976	15	18	70	1	3	-	1
upper Ottawa River 1976	-	-	-	36	11	-	-
lower Ottawa River 1977	-	33	28	10	18	-	-
Upper Ottawa River 1977	-	-	15	123	47	3	-

Table 1. Averaged chemical and physical characteristics of Ottawa River water at each station for the past few years. Bottom and surface values are averaged. All units are expressed in ppm unless otherwise indicated. For each parameter and station, the range is followed by the mean,  $\pm$  standard error and number of samples.

Parameters	Stations					
	Britannia Bay	Brewery Creek	Upper Tip of Kettle Island	North Channel	South Channel	Kettle Island Bay
pH	6.8-7.5 7.3 0.081 13	6.6-7.5 6.9 0.052 17	6.7-7.3 7.0 0.034 18	6.5-7.1 6.8 0.055 14	6.5-7.0 6.7 0.057 11	6.9-7.6 7.22 0.04 22
Dissolved O <sub>2</sub>	7.0-13.0 9.6 0.445 13	7.0-12.0 8.1 0.751 17	7.0-11.0 9.0 0.277 18	7.5-10.0 8.9 0.278 14	5.0-9.5 7.8 0.532 11	7.0-11.0 8.44 0.19 22
Dissolved CO <sub>2</sub>	4.0-10.0 7.4 0.783 12	5.0-10.0 10.5 0.943 16	5.0-10.0 9.1 0.442 17	5.0-11.0 9.2 0.505 14	10.0-17.5 11.5 0.829 10	4.0-12.0 7.95 0.19 22
Hardness (Total)	22.0-51.3 34.4 2.838 12	25.0-90.5 48.1 5.749 14	20.5-54.5 37.5 3.691 12	20.5-70.0 33.2 3.805 14	24.0-70.0 38.7 3.825 13	20.0-45.0 30.77 1.39 22
Turbidity (Jackson turbidity units)	8.5-45.0 21.9 3.255 14	10.0-40.0 23.6 3.196 15	9.5-20.5 16.0 1.187 14	8.0-33.0 16.7 1.605 16	16.5-41.0 29.0 2.282 15	- - - -
Temperature (°C)	4.4-23.6 17.2 - 37	5.6-22.2 17.2 - 37	6.1-22.8 17.1 - 35	7.4-22.5 17.0 - 21	- - - -	14.5-30.0 21.8 0.71 25

The dash lines do not mean that no fish were caught in those months, but that no fishing was done in the lower and upper Ottawa River during those months. The sole exception is in the upper Ottawa river in June 1976 when angling was done fairly frequently and no fish were caught.

Throughout the course of the field work, six gill nets were used, five of which were 61 m long by 1.8 m deep with four gangs of 101.6, 76.2, 50.8 and 38.1 mm stretched mesh; one gill net was 76 m long by 1.8 m deep with five gangs of 101.6, 76.2, 50.8, and 38.1 mm and 25.4 mm stretched mesh. Various hoop nets and seine nets were used but no fish were caught in these. Plankton nets were used to collect the larvae of mooneye but to no avail.

Gill nets were set in the morning and left overnight. In deep waters the nets were hung at various depths.

In 1976, netting was done regularly during a three week period in June, while in July and August, only three samples were taken each month. Gill nets placed for one week in October yielded one fish. In 1977, netting was done daily during the latter part of May, intensely during June, July and August, and once in September.

#### Age Determination and Validation of Aging Structures

All fish were measured in cm and weighed in grams before freezing. Both fork length (F.L.) and total length (T.L.) were measured.

Scales and otoliths were removed after capture and stored in coin envelopes. Scales, removed from the left-hand side below the

lateral line, were imprinted on vinyl slides (0.5 mm thick) with a Jeweller's Press (Butler and Smith, 1953; Chugunova, 1963). Scales were then read with a Bausch and Lomb scale projector (Lagler, 1956). The length from the focus of the scale to each annulus was recorded, as was the length for the total radius along the antero-lateral side of the scale. All scales were read two to four times along the same radius for confirmation.

Otoliths were read twice using an M5 Wild binocular stereoscope. No processing of otoliths was necessary.

Vertebrae were removed after the fish had been frozen for about 6-9 months. Only one or two vertebrae were examined per fish; these being either numbers 12, 13, 14 or 15. Once removed, vertebrae were placed in 2N KOH for 48 hours after which the remaining flesh was removed with tweezers and the vertebrae air-dried. They were then studied with an M5 Wild binocular stereoscope (Appelget and Smith, 1951).

A comparison was made between the ages obtained from scales, otoliths, and vertebrae of a given fish. A sample of 56 fish was used for this study. Due to the fact that the correlation of the ages determined by these three structures was similar, the aging of fish was done with scales for the remainder of the study, for it is the simplest and quickest way of age determination.

#### Growth Analysis

The backcalculations were done in order to determine the total lengths of fish at each age prior to capture. The Lee Method,

as explained by Carlander (1977) was used for backcalculating total lengths:

$$L_n = a + \frac{S_n}{S} (L - a)$$

where  $L$  = total length of fish at capture

$S$  = scale radius

$S_n$  = length of scale at end of each annulus

$L_n$  = total length of fish corresponding to  $S_n$

$a$  = total body length intercept

This equation assumes a scale radius versus total body length linear regression and a y-intercept other than zero. Backcalculated total lengths were derived for fish in the lower and upper Ottawa River in both 1976 and 1977.

Weighted mean backcalculated total lengths and average annual growth increments for each year class were computed. The average annual growth increment is the difference in successive weighted mean total lengths. It is the average growth in total length in one year.

The Student's t-test at the 95% confidence level was used in comparing the weighted mean backcalculated total lengths and the average annual growth increments for each location and year of study. This test does not assume that the variances are equal (Dixon and Massey, 1951).

Total length-age, weight-age, and weight-total length relationships were done. To describe the weight-total length relationship the following equation was applied (Le Cren, 1951):

$$\log W = m \log L + b$$

Standard error and analysis of variance were done for each of the above relationships. Stored computer programs at the Ottawa University Computer Center were used and significant differences at the .05 level were not observed between growth in total length and weight for females and males in the lower and upper Ottawa River, so sexes were combined.

In comparing the relative well-being or plumpness of the fish in the lower and upper Ottawa River, Fulton's condition factor was used (Carlander, 1977):

$$K = \frac{W 10^5}{L^3}$$

where W = weight (g)

L = total length (cm)

$L^3$  is used because the value of b in the total length-weight regression is very close to three. With this condition factor it is possible to see if the fish is growing well in its habitat and whether sex, season, and location has any effect on its growth.

Condition factors for the sexes separate and combined were computed for the lower and upper Ottawa River. Differences between these groups were obtained for each age class using the Student's t-test at the 95% level. Confidence limits (95%) were also determined for each age class in each location.

Relative growth was computed in the following manner (Ricker, 1975):

$$R.G. = \frac{W_2 - W_1}{W_1} \times 100$$

where  $W_1$  = mean weight of a specific year class  
 $W_2$  = mean weight of the following higher year class

It expresses a percent change in size for a certain period of time, which, in this case is one year. The test for differences of percentages at the 95% confidence level (Hogg and Tanis, 1977) was used to compare relative growth in the lower and upper Ottawa River for each comparable age class.

The von Bertalanffy growth model is used in this study as a convenient description of the growth data (Ricker, 1958):

$$L_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

where  $L_t$  = total length at a specific age  
 $L_{\infty}$  = ultimate total length  
 $K$  = growth rate  
 $t$  = age corresponding to  $L_t$   
 $t_0$  = age at which the von Bertalanffy equation applies (Allen, 1966)

An indication of ultimate fish total length for a particular area and a growth estimate in the form of the straight line equation can be provided using Walford plots (Everhart et al., 1975). The weighted mean of backcalculated total lengths at each annulus for each year class was determined and the total length at age  $t + 1$  was plotted

against the total length at age  $t$ . After having established the linear regression formula, the parameters  $K$  and  $L_{\infty}$  can be computed whereby:

$$K = -\ln \text{ slope of the Walford line}$$

$$L_{\infty} = \frac{\text{intercept}}{1 - \text{slope}}$$

The slope is an expression of the rate of growth while  $L_{\infty}$  is the ultimate total length toward which a fish grows. A graphical representation of  $L_{\infty}$  is also possible. This is accomplished by drawing a  $45^{\circ}$  line in the graph of total length <sub>$t+1$</sub>  versus total length <sub>$t$</sub> . The ultimate total length is the point at which the Walford line intersects the  $45^{\circ}$  line.

The parameter  $t_0$  can be obtained by plotting  $\ln(L_{\infty} - l_t)$  versus age ( $t$ ) and computing (Everhart et al., 1975):

$$t_0 = \frac{\text{intercept} - \ln L_{\infty}}{K}$$

With the parameters  $K$ ,  $L_{\infty}$ , and  $t_0$ , the von Bertalanffy equation can be established.

#### Stomach Content Analysis

Stomach contents were removed from the J-shaped stomach after the catch, and preserved in 10% formalin. In 1976 and 1977, 120 and 275 fish were analyzed for stomach contents respectively. The number

of fish taken for stomach analysis each month in the lower and upper Ottawa River in 1976 and 1977 is found in the following table.

Table 3. Number of fish used for stomach analysis each month in the lower and upper Ottawa River, 1976-1977.

	May	June	July	August	September
lower Ottawa River 1976	-	69	1	3	-
upper Ottawa River 1976	-	-	36	11	-
lower Ottawa River 1977	-	28	9	17	-
upper Ottawa River 1977	33	15	123	47	3

The dash lines mean no fishing was done in those months. However, in May in the lower Ottawa River, 1976, 33 fish were caught but not kept for stomach analysis.

Most organisms, other than Pelecypoda and Arachnida, were identified to order. Wherever possible, Odonata were further identified to sub-order Zygoptera, while Hymenoptera were identified down to the family Formicidae because large numbers of them were found (Needham and Needham, 1962; Barnes, 1974; Borror *et al.*, 1976).

Three methods of studying food habits were employed, namely, numerical, frequency of occurrence and the volumetric methods (Hynes, 1950; Lagler, 1956).

The numerical method consists of counting every organism found in a stomach. They were identified using an M5 Wild binocular stereoscope and placed in vials containing 45% alcohol. For each location, the number of different organisms and the percent of organisms consumed per fish per age class was established. Using the six most

common food items found, histograms were constructed for each year and location.

The frequency of occurrence method is expressed as a percentage of the number of individual samples in which a specific organism is found.

The volumetric method entails reading the volume displacement (to .01 ml) in a graduated cylinder of food organisms found in each age class of mooneye. These volumes were converted to percentages for each age class. Pie diagrams were then constructed with this data.

#### Maturity, Fecundity, and Egg Diameter

Gonads were removed from the fresh fish, weighed to the nearest gram and frozen. In the mature male, the anterior rays of the anal fin become extended and a distinct lobe is apparent (Fig. 34). In addition, a depression is noticed on the body adjacent to this fleshy lobe. During the spawning season, mature males and females have a pinkish hue on their fins and bellies.

The sex and state of sexual maturity was assessed by visual inspection. Testes of immature males are characterized by straight transparent tubules while those of mature males have thick lobulated sacs. Immature females have white ovaries with no eggs visible to the naked eye. Ovaries of mature females are creamy with visible eggs. Ripe ovaries are blue-grey in color (Johnson, 1951).

The volumetric method was used in determining the number of eggs present. Approximately 500 eggs were counted from the upper quadrant of the left ovary after removal of the connective tissue and

their volume taken. Subsequently, the volume of the two ovaries, with connective tissue removed, was taken and the total number of eggs estimated volumetrically.

Relative and total fecundity was determined for all ripe mooneye. Relative fecundity is the number of eggs per 100 grams of body weight, while total fecundity is the number of eggs in both ovaries per ripe female. Also considered is the Gonadosomatic Index (GSI) which is the gonad weight expressed as a percentage of body weight.

Egg diameter for ripe females was determined with a scale micrometer to the nearest .01 mm. Eight to ten eggs per female were placed in a row, measured, and the mean taken.

#### Proximate analysis\*

Proximate analysis was done to assess the differences in percent moisture, fat, and protein in fish muscle for both male and female mooneye in 1977. Fish were chosen on the basis of weight. Fish specimens ranged in size from 66.5 g to 718.5 g with samples taken, whenever possible, every 20 g.

Homogenization was necessary for each of the 28 fish used in fish muscle analysis. A meat grinder was used to get the sample down to a coarse texture. The sample was then transferred to a Sorval Omni-Mixer (model #17105) and homogenized until the mixture resembled

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\* "The analysis of the four main tissue constituents, protein, water, lipid and ash is sometimes described as "Proximate analysis". The etymology of the word is uncertain, but the accuracy of the determinations is presumably not in doubt." The Chemical Biology of Fishes. R.M. Love. p. 260. 1970.

a fine paste.

Samples of the mixture were weighed on filter paper to 2 - 2.5 g. They were analyzed at Agriculture Canada Food Laboratory according to the methods outlined by Horwitz (1975). The Kjeldahl Method was used for protein analysis (section 24.024). The methods for the determination of fat and moisture are found in the same manual under sections 24.005 and 24.002 respectively.

The Student's  $t$ -test at the 95% confidence level was used in determining significant differences between males and females in various weight classes.

## RESULTS

## Age and Growth

## Comparison of structures used

A comparison of three structures, scales, otoliths, and vertebrae, was undertaken in order to determine their validity for aging. The percent agreement between each of these structures is given in Table 4. Since a 93 percent agreement was found between the three structures, scales were used for aging the fish.

Table 4. Comparison of aging structures for mooneye in the Ottawa River.

Aging structures	Number of specimens	Percent agreement
scales and otoliths	47 <sup>a</sup>	94
scales and vertebrae	56	98
otoliths and vertebrae	45 <sup>a</sup>	93
scales, otoliths, and vertebrae	45 <sup>a</sup>	93

a. Number of samples out of a total of 56 randomly selected specimens in good enough condition for aging.

## Annual growth

The linear regression equations for scale radius (S.R.) versus total body length (T.L.) for the lower and upper Ottawa river for both years of study are:

lower Ottawa River 1976: S.R. = 0.2355 T.L. - 0.9022 N = 107, r = 0.52  
 upper Ottawa River 1976: S.R. = 0.1874 T.L. - 0.0254 N = 47, r = 0.73  
 lower Ottawa River 1977: S.R. = 0.2156 T.L. - 0.6873 N = 89, r = 0.84  
 upper Ottawa River 1977: S.R. = 0.2063 T.L. - 0.0385 N = 188, r = 0.93

In all cases, total body lengths were obtained from the equations using known scale radii to verify if the calculated total length values compared well with those obtained in the field. This was done in order to check the validity of the equations. There were no significant differences between the calculated and measured total body lengths.

The total body length intercepts, calculated from the above equations are used to determine backcalculations (Tables 5 to 8). For instance, when the scale radius is zero, total body length can be computed as the intercept of the graph of scale radius versus body length divided by the slope of the regression equation. This total body length intercept is subtracted from the length of the fish at capture in the formula for backcalculations which appears in Materials and Methods. The discrepancy between the last backcalculated total lengths and the average total lengths observed at capture is due to the fact that the captured fish has already begun, and in some cases, mostly completed its next year of growth. Generally, the Rosa Lee phenomenon exists, whereby backcalculated total lengths of older fish in earlier years are lower than those observed for younger fish caught during the study, although exceptions do occur. For instance, the backcalculated total length after the first year for 8 year old fish is ~~10.7~~ 10.7 cm while it is 12.2 cm when backcalculated from two year olds (Table 7). In these situations where young mooneye were not caught (Tables 5, 6, and 8), this phenomenon is not apparent for the backcalculated total lengths of yearling fish, and in one instance (Table 5), it does not exist at all. These irregularities are most likely due to the lack of younger

Table 5. Average backcalculated total lengths of mooneye collected from the lower Ottawa River in 1976.

Age	Number of fish	Average total length at capture (cm)	Calculated total length (cm) at each annulus										
			1	2	3	4	5	6	7	8			
IV	10	28.6	10.3	17.4	23.4	27.3							
V	30	30.2	10.8	17.8	23.4	27.1	29.4						
VI	45	31.2	10.9	17.8	23.0	26.4	28.9	30.5					
VII	17	32.3	11.0	18.3	23.3	26.6	28.7	30.3	31.6				
VIII	6	33.0	10.9	19.7	24.3	27.1	29.0	30.3	31.5	32.5			
Weighted mean total length			10.8	17.9	23.3	26.7	29.0	30.4	31.6	32.5			
Average annual growth increment			10.8	7.1	5.4	3.4	2.3	1.4	1.2	0.9			
Number of fish			108	108	108	108	98	68	23	6			

Table 6. Average backcalculated total lengths of mooneye collected from the upper Ottawa River in 1976.

Age	Number of fish	Average total length at capture (cm)	Calculated total length (cm) at each annulus														
			1	2	3	4	5	6	7	8	9	10	11	12			
IV	1	30.0	10.3	19.2	24.2	28.3											
V	5	30.3	7.4	14.5	21.9	25.9	29.4										
VI	5	31.3	7.5	15.4	20.4	23.6	27.0	30.2									
VII	9	33.7	7.4	14.9	21.7	25.9	29.8	32.0	33.2								
VIII	9	35.2	6.9	14.5	21.8	26.1	29.9	31.9	33.5	34.6							
IX	3	36.3	6.8	12.7	20.4	25.0	28.3	30.8	32.8	34.9	35.8						
X	4	38.7	8.5	15.0	22.3	27.0	30.4	32.4	34.1	35.6	36.8	38.1					
XI	9	38.0	7.2	14.0	20.5	25.1	28.1	30.7	32.4	33.9	35.1	36.3	37.3				
XII	2	38.6	8.0	15.6	21.7	25.4	29.2	31.8	33.5	34.6	36.0	36.8	37.6	38.2			
Weighted mean total length			7.4	14.7	21.4	25.6	29.1	31.4	33.2	34.5	35.7	36.8	37.4	38.2			
Average annual growth increment			7.4	7.3	6.7	4.2	3.5	2.3	1.8	1.3	1.2	1.1	0.6	0.8			
Number of fish			47	47	47	47	46	41	36	27	18	15	11	2			

Table 7. Average backcalculated total lengths of mooneye collected from the lower Ottawa River in 1977.

Age	Number of fish	Average total length at capture (cm)	Calculated total length (cm) at each annulus										
			1	2	3	4	5	6	7	8			
I	3	19.8	11.3										
II	16	21.5	12.2	19.7									
III	9	26.1	10.6	17.9	23.8								
IV	13	28.4	9.8	17.5	23.4	27.1							
V	18	30.2	10.1	16.9	22.8	26.7	29.2						
VI	19	31.3	10.6	17.4	22.6	26.2	28.9	30.7					
VII	8	31.6	10.6	17.3	22.1	25.2	27.4	29.3	31.0				
VIII	3	32.7	10.7	17.1	22.4	25.3	27.5	29.5	31.0	32.2			
Weighted mean total length			10.7	17.8	22.9	26.4	28.7	30.2	31.0	32.2			
Average annual growth increment			10.7	7.1	5.1	3.5	2.3	1.5	0.8	1.2			
Number of fish			89	86	70	61	48	30	11	3			

Table 8. Average backcalculated total lengths of mooneye collected from the upper Ottawa River in 1977.

Age	Number of fish	Average total length at capture (cm)	Calculated total length (cm) at each annulus															
			1	2	3	4	5	6	7	8	9	10	11	12	13			
III	4	26.5	6.6	17.2	24.9													
IV	10	29.6	6.7	15.5	23.4	28.3												
V	17	31.8	7.3	15.8	22.8	27.3	30.5											
VI	33	33.0	7.6	15.6	22.5	26.8	30.1	32.2										
VII	30	33.9	6.8	14.3	21.4	26.1	29.4	31.6	33.2									
VIII	25	35.6	6.7	14.4	21.3	25.9	28.3	31.7	33.6	34.9								
IX	26	36.7	7.2	15.0	21.7	26.0	29.5	31.9	33.6	35.0	36.2							
X	17	37.5	7.2	14.8	21.7	26.2	29.7	31.6	33.4	34.8	35.9	36.9						
XI	14	37.8	7.4	14.9	20.7	24.8	28.0	30.4	32.4	34.2	35.5	36.6	37.5					
XII	5	38.3	6.5	13.7	20.8	25.2	28.5	30.5	32.3	33.6	34.8	36.0	37.0	37.8				
XIII	1	39.1	6.6	13.7	20.6	24.7	27.7	30.1	32.5	33.6	35.0	36.1	36.9	37.9	38.7			
Weighted mean total length			7.1	15.0	21.9	26.3	29.4	31.6	33.3	34.7	35.8	36.6	37.3	37.8	38.7			
Average annual growth increment			7.1	7.9	6.9	4.4	3.1	2.2	1.7	1.4	1.1	0.8	0.7	0.5	0.9			
Number of fish			182	182	182	178	168	151	118	88	63	37	20	6	1			

fish in the sample.

Generally, the backcalculated total lengths for the lower Ottawa River are greater than those estimated for the upper Ottawa River for ages one through four (Tables 5 to 8). The backcalculated values for fish aged one through four, obtained for seven year old fish in the lower Ottawa River, 1976 are 11.0, 18.3, 23.3 and 26.6 cm respectively (Table 5), while those for seven year olds in the upper Ottawa River, 1976 are 7.4, 14.9, 21.7, and 25.9 cm respectively (Table 6). Beyond age four, the upper Ottawa River backcalculated total lengths are greater than those of the lower Ottawa River. For instance, upper Ottawa River eight year olds in 1977 have backcalculated values in their fifth, sixth, seventh, and eighth years of 28.3, 31.7, 33.6, and 34.9 cm respectively (Table 8), while the backcalculated values of eight year olds in the lower Ottawa River, in corresponding years are, 27.5, 29.5, 31.0 and 32.2 cm respectively (Table 7). This may be caused by a lack of mooneye less than three years of age and also to the fact that backcalculated total lengths for upper Ottawa River mooneye were done from much older fish than in the lower Ottawa River.

The weighted mean total lengths increase with an increase in age while the average annual growth increments decrease with age (Tables 5 to 8). In the lower Ottawa River in 1976 the weighted mean total length at the end of the first year is 10.8 cm and increases yearly, until mooneye attain, at the end of the eighth year, a mean total length of 32.5 cm (Table 5). According to the backcalculations, maximum growth occurs during the first year of life and decreases steadily. In the case of lower Ottawa River mooneye in 1976, fish grew 10.8 cm in year one

and only 1.2 cm during year seven (Table 5).

In both areas of the river, a comparison of males and females with respect to weight, length, and age revealed no significant differences. Sexes were combined in a series of graphs (Fig. 2 to 13). In the lower Ottawa River, 1976 fish younger than four years were not caught while in 1976 and 1977 fish older than eight years were not caught. Significant differences in length between these two years were not observed. The latter also applies to the upper Ottawa River in 1976 and 1977 (Fig. 3). The maximum age attained in the upper Ottawa River is 13 years while the youngest fish caught is three years. The same pattern exists here as in the lower Ottawa River where younger fish grow more quickly than older fish.

Graphs, depicting the total length-age, weight-age, and weight-total length relationships, were constructed using data for the months common to both the lower and upper Ottawa River. When these graphs were compared to the graphs presented in Fig. 2 to 12, the growth patterns were similar. Thus, the first series of graphs were omitted. Furthermore, during the summer months, Ottawa River mooneye do not change significantly in total length and weight at the same age. Therefore, the grouping of fish data for various months seems appropriate.

Significant difference ( $P \leq .05$ ) in growth patterns in the two areas for each year of study do occur with few exceptions (Fig. 4 and 5). These exceptions occur at ages five and six in 1976 and at ages three and four in 1977. This may be due to small sample size.

The growth pattern is better defined in Figure 5. This graph well depicts the rapid growth in young fish and the tapering off of growth

Fig. 2. Total length-age relationship of mooneye collected from the lower Ottawa River in 1976 and 1977. The mean, standard errors, and number of specimens on bars are shown.

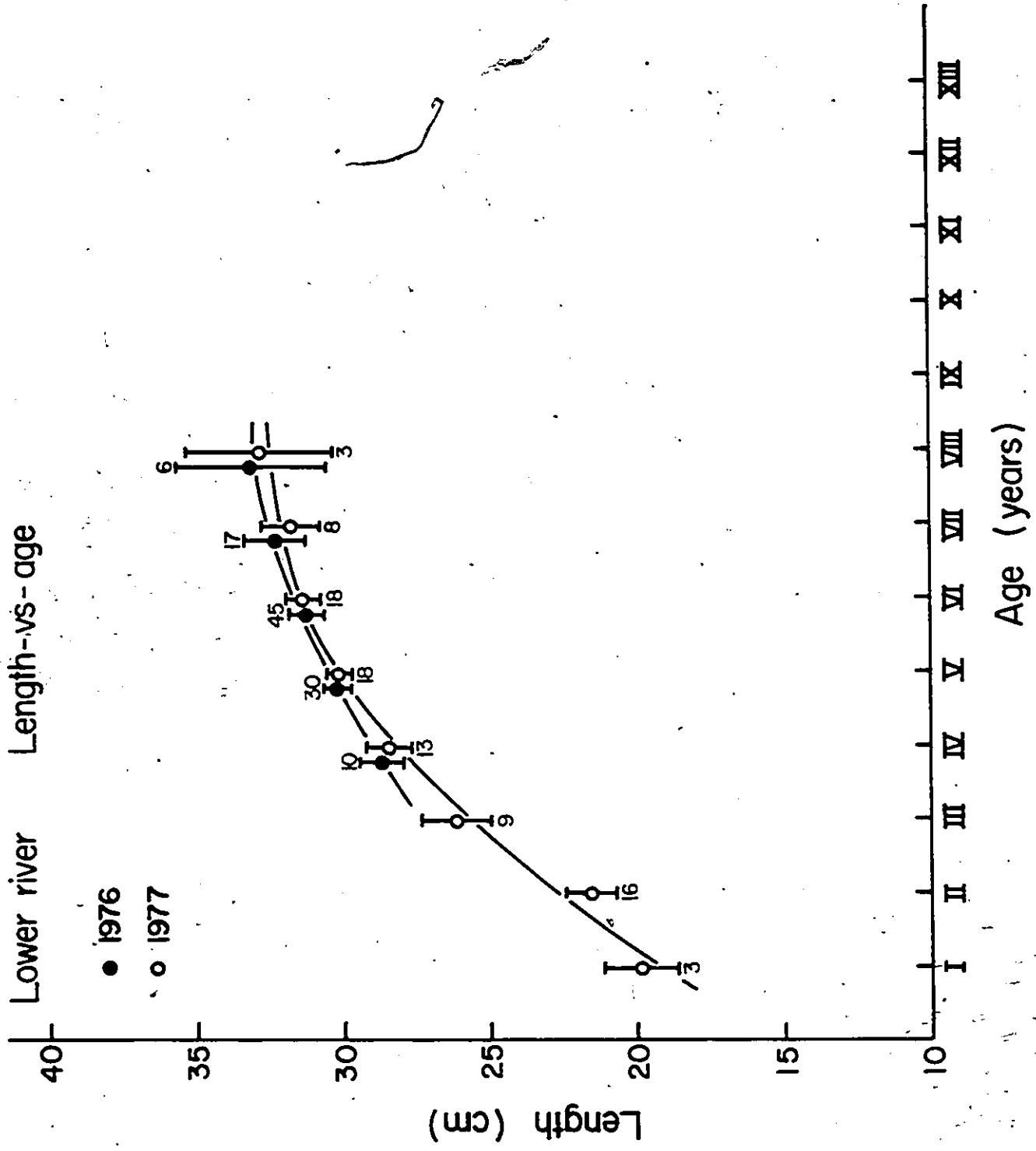


Fig. 3. Total length-age relationship of mooneye collected from the upper Ottawa River in 1976 and 1977. The mean, standard errors, and number of specimens on bars are shown.

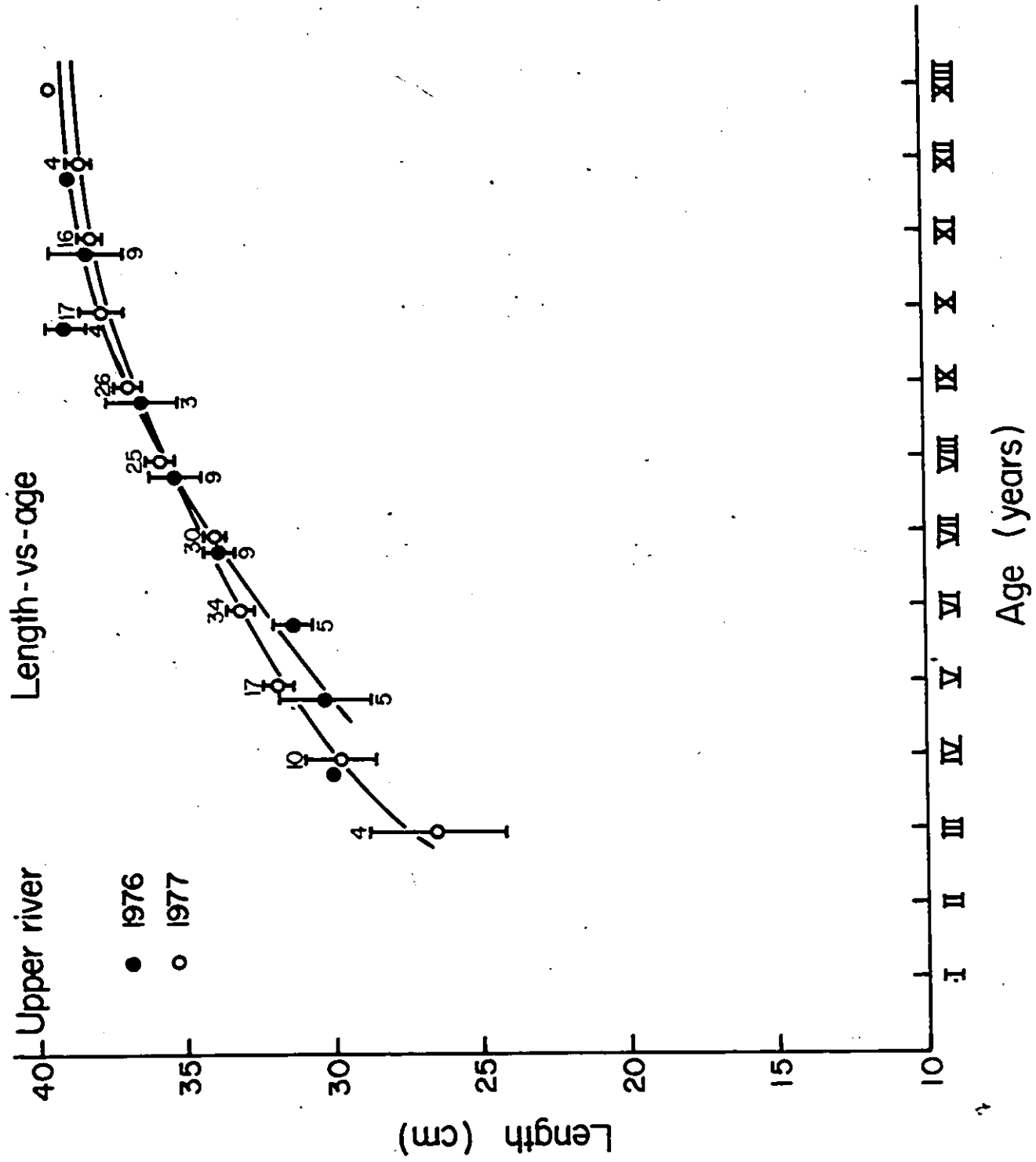


Fig. 4. Total length-age relationship of mooneye collected from the lower and upper Ottawa River in 1976. The mean, standard errors, and number of specimens on bars are shown.

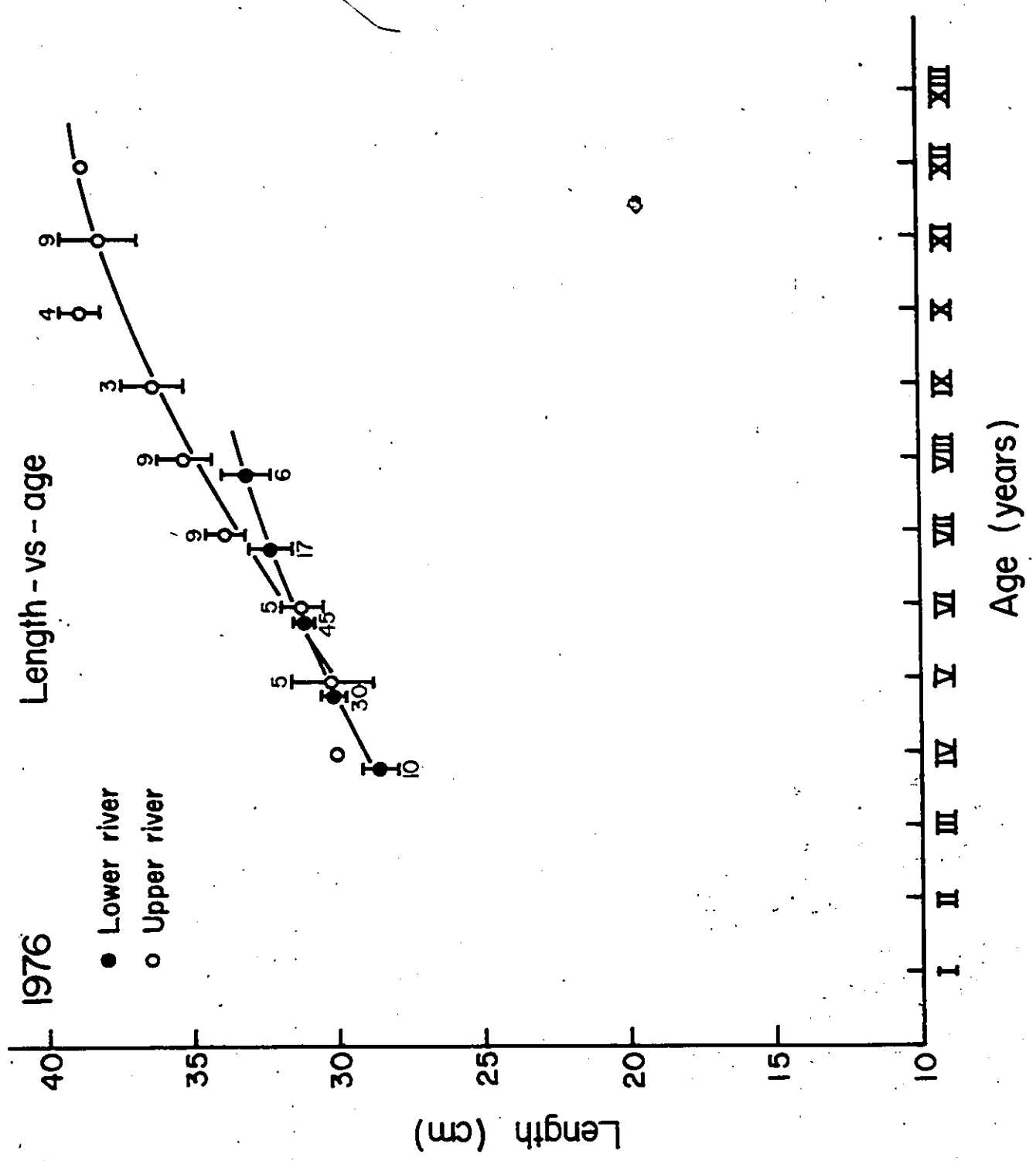
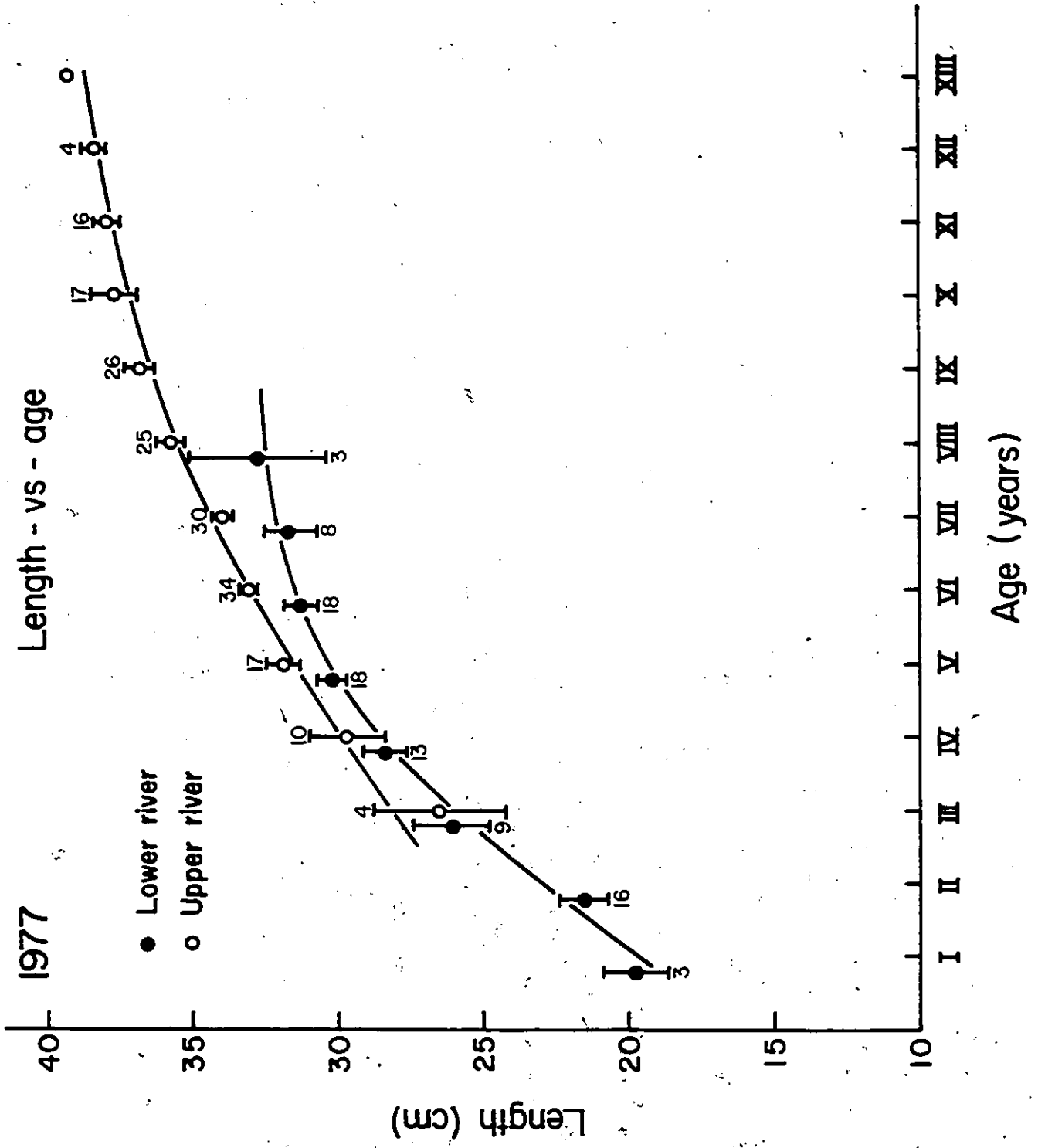


Fig. 5. Total length-age relationship of mooneye collected from the lower and upper Ottawa River in 1977. The mean, standard errors, and number of specimens on bars are shown.



in older fish. Mooneye from the lower Ottawa River are significantly ( $P \leq .05$ ) smaller than those from the upper Ottawa River at any age.

There exists a rapid increase in weight of young mooneye with no significant differences between those caught in 1976 and 1977 in the lower Ottawa River (Fig. 6). When older age groups are sampled, weight gain lessens (Fig. 7). Generally, during both years in the upper Ottawa River no significant differences in weight are found for fish of the same age.

Upper Ottawa River fish weigh significantly ( $P \leq .05$ ) more than lower Ottawa River fish at any given age, except for ages five and three in 1976 and 1977 respectively (Fig. 8 and 9). Upper Ottawa River mooneye gain weight for a longer period of time than do those from the lower Ottawa River. The weight gain from one year to the next slows down at a much younger age for lower Ottawa River fish.

Weight-total length relationships were constructed for the lower and upper Ottawa River in 1976 and 1977 (Fig. 10 to 13). No significant differences ( $P \leq .05$ ) in weight are found in the lower and upper Ottawa River during both years for fish of the same total length (Fig. 10 and 11). However, when the two areas are compared during each year, significant differences are obtained (Fig. 12 and 13). For instance, the mean weight 276.0 g corresponding to the mean total length 30.6 cm, for mooneye caught in the lower Ottawa River during 1976, differs significantly ( $P \leq .05$ ) from the mean weight of 327.2 g for mooneye of the same total length in the upper Ottawa River 1976 (Fig. 12).

Since upper Ottawa River mooneye at all ages grow longer and heavier at a specific age than lower Ottawa River mooneye, it is

Fig. 6. Weight-age relationship of mooneye collected from the lower Ottawa River in 1976 and 1977. The mean, standard errors, and number of specimens on bars are shown.

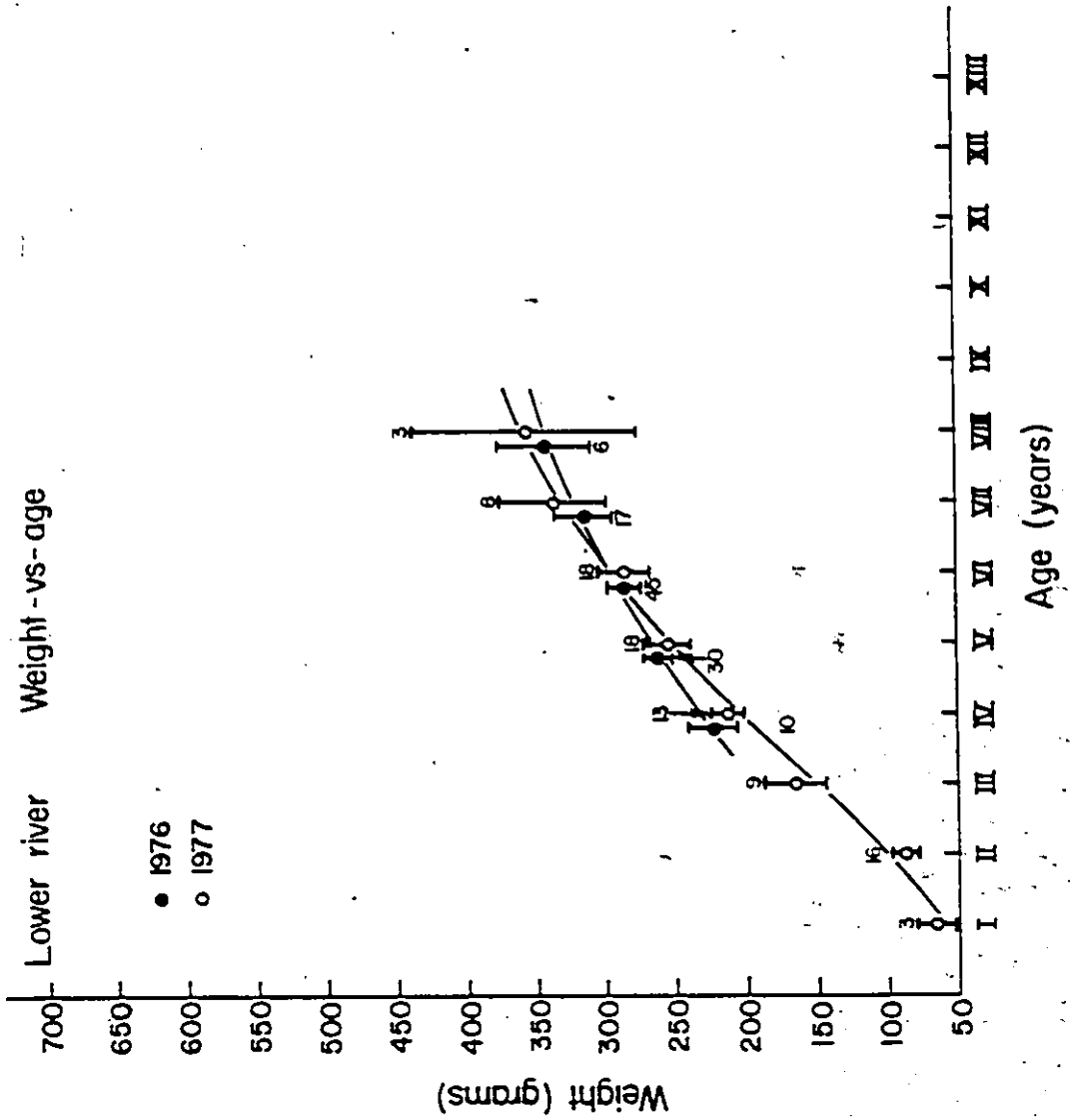
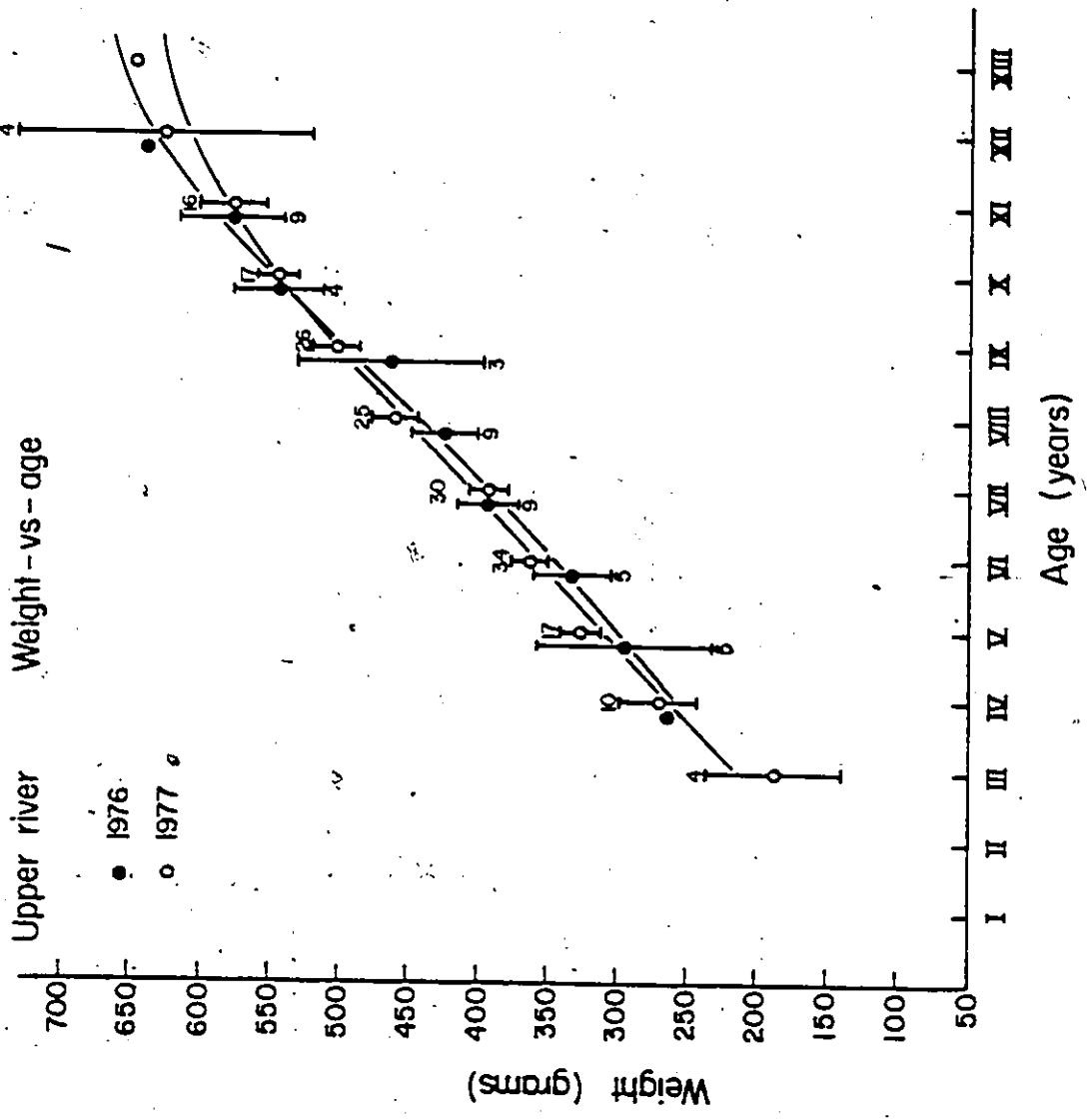


Fig. 7. Weight-age relationship of mooneye collected from the upper Ottawa River in 1976 and 1977. The mean, standard errors, and number of specimens on bars are shown.



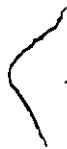


Fig. 8. Weight-age relationship of mooneye collected from the lower and upper Ottawa River in 1976. The mean, standard errors, and number of specimens on bars are shown.

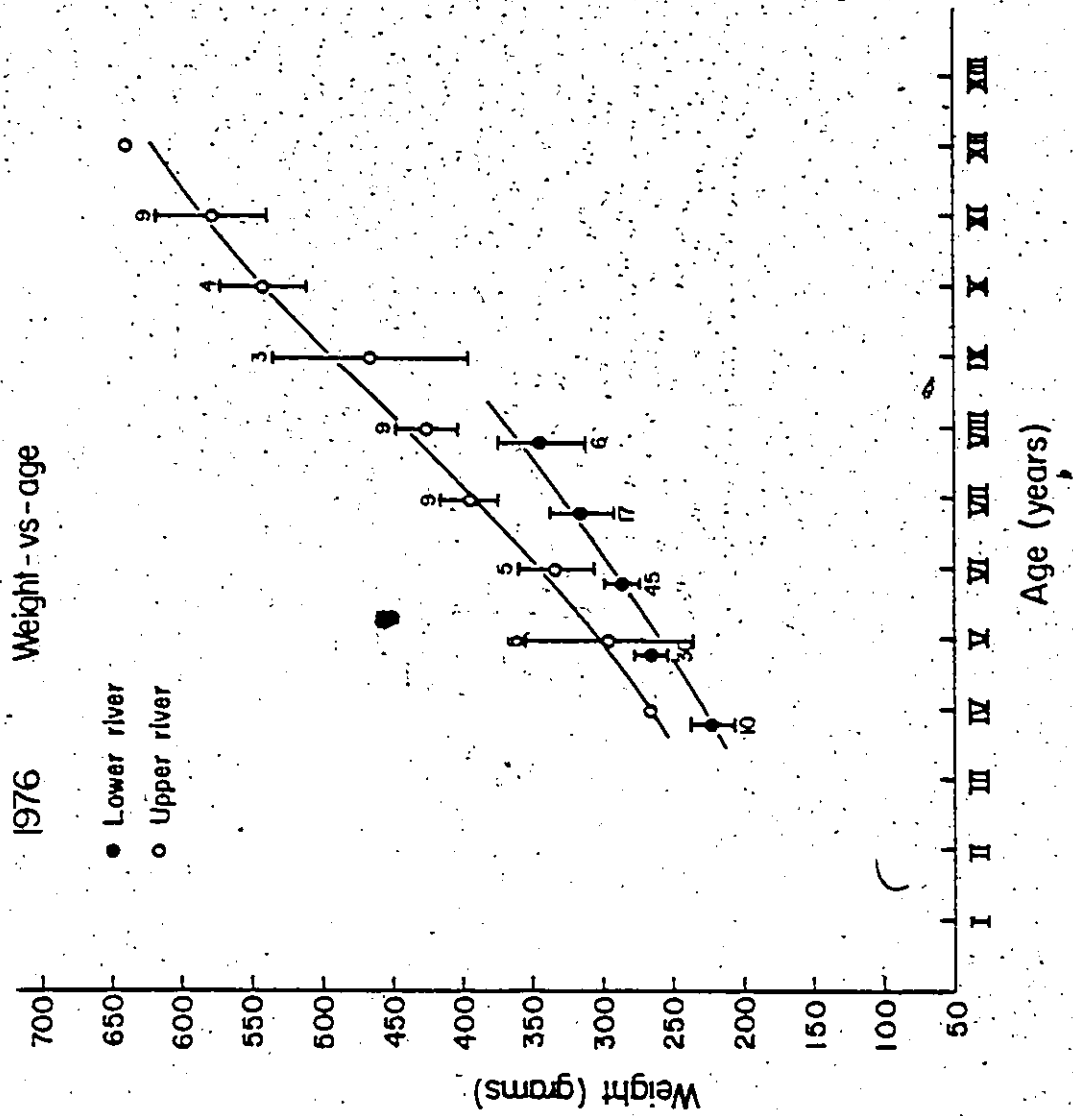


Fig. 9. Weight-age relationship of mooneye collected from the lower and upper Ottawa River in 1977. The mean, standard errors, and number of specimens on bars are shown.

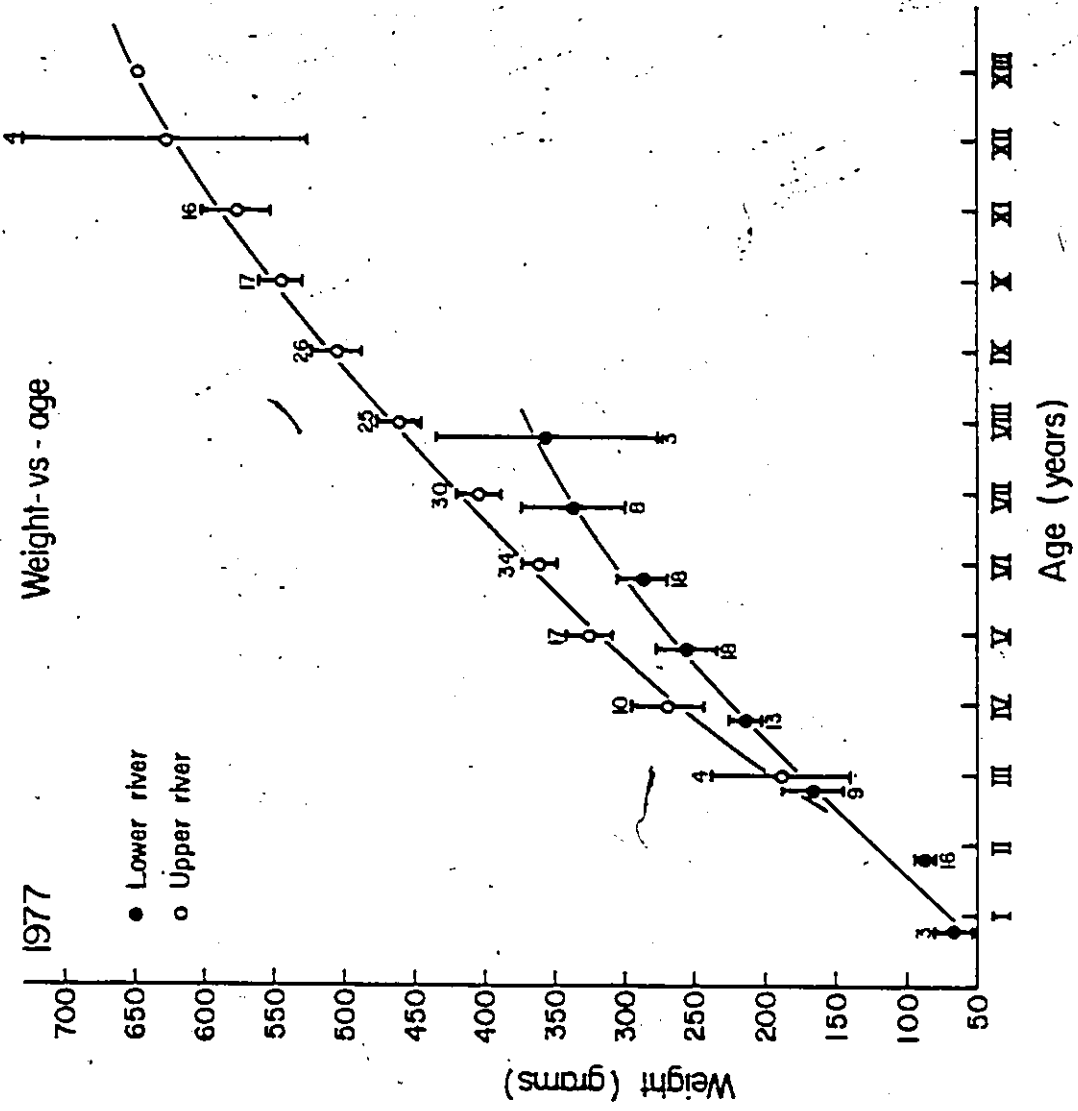


Fig. 10. Weight-total length relationship of mooneye collected from the lower Ottawa River in 1976 and 1977. The mean, standard errors, and number of specimens on bars are shown.

# Weight - vs - length

Lower river

1976 • log W = 2.5468 log L - 1.3501 N = 108 r = 0.83

1977 ○ log W = 3.0945 log L - 2.1645 N = 88 r = 0.98

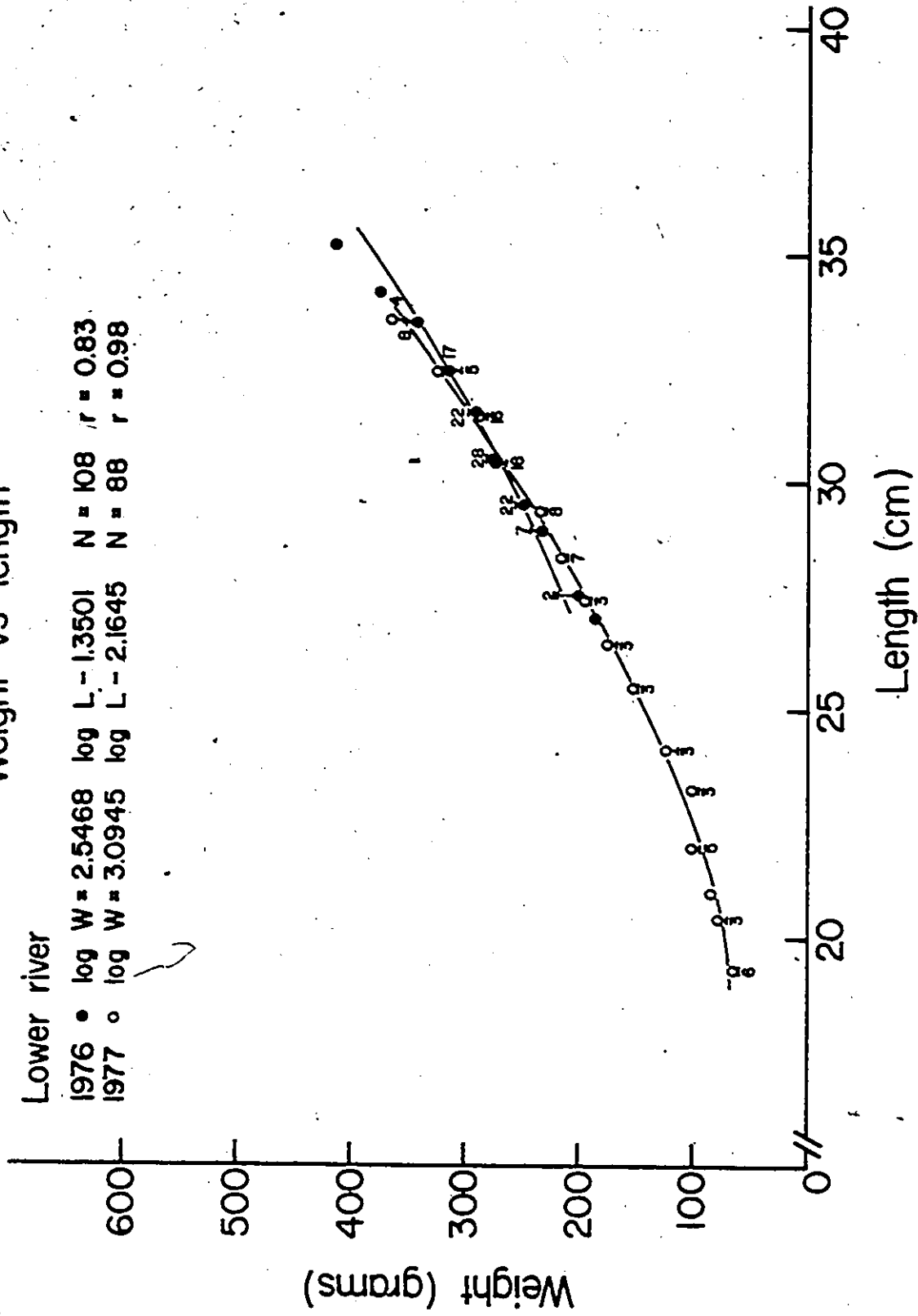


Fig. 11. Weight-total length relationship of mooneye collected from the upper Ottawa River in 1976 and 1977. The mean, standard errors, and number of specimens on bars are shown.

# Weight - vs - length

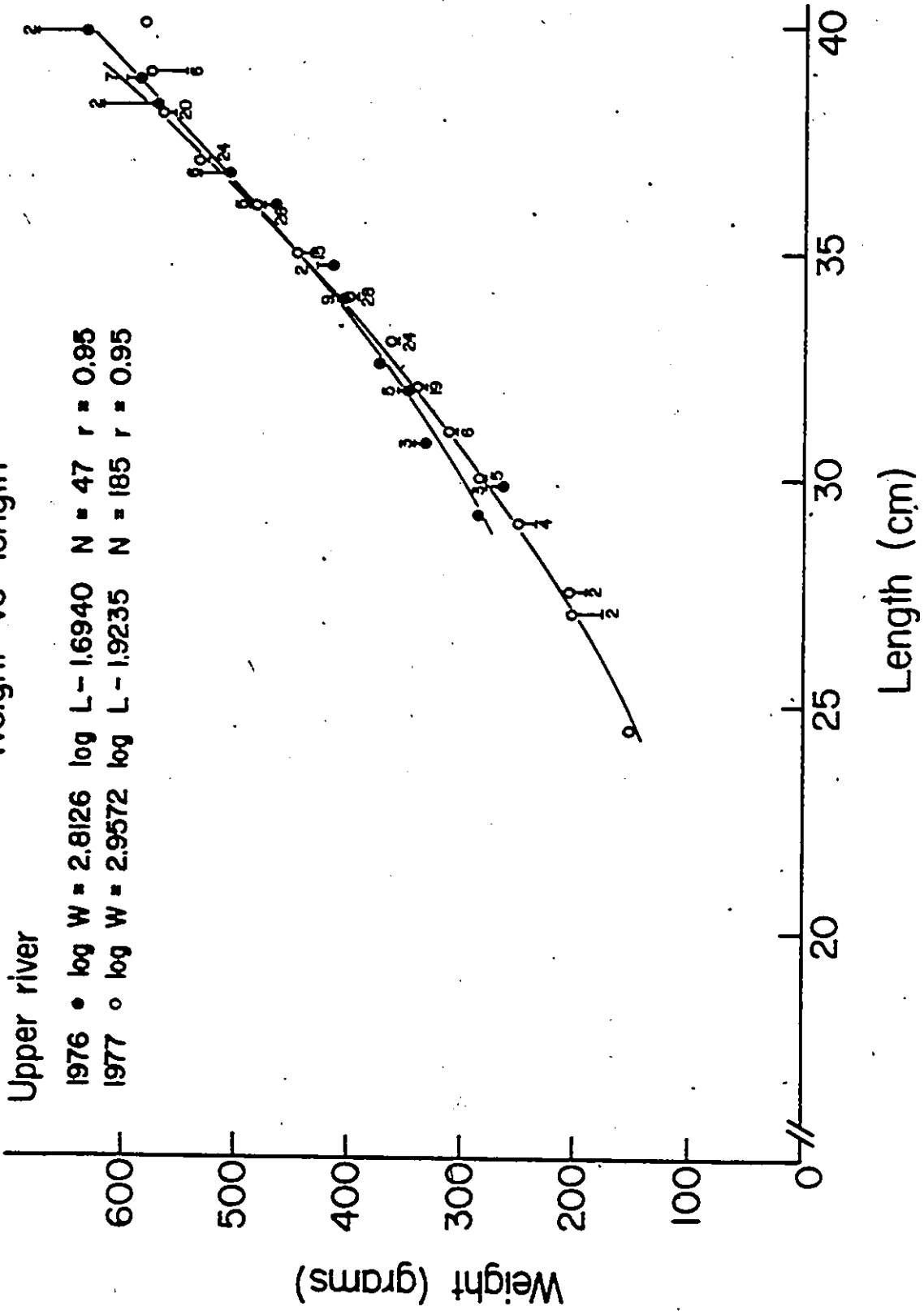


Fig. 12. Weight-total length relationship of mooneye collected from the lower and upper Ottawa River in 1976. The mean, standard errors, and number of specimens on bars are shown.

# Weight - vs - length

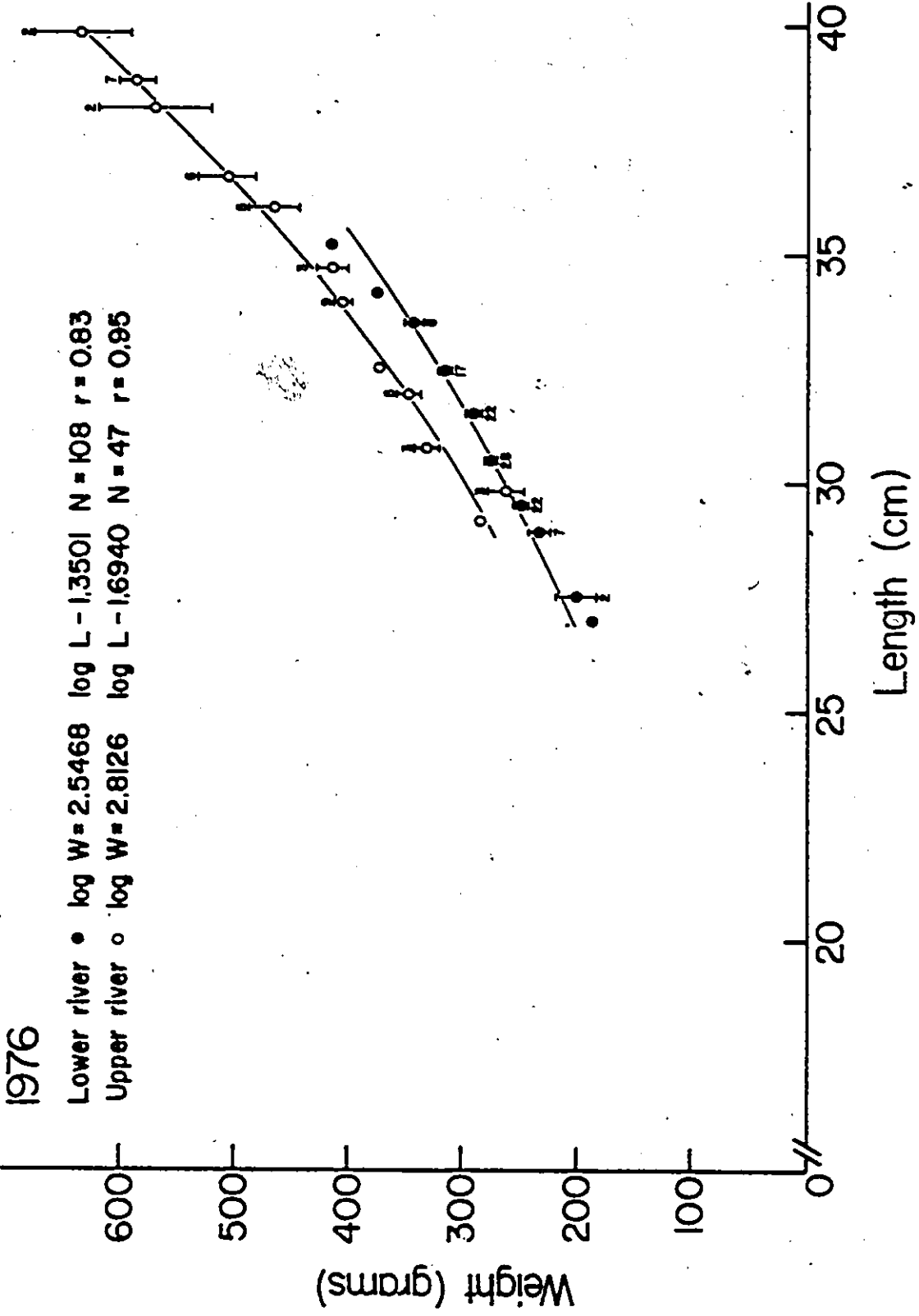
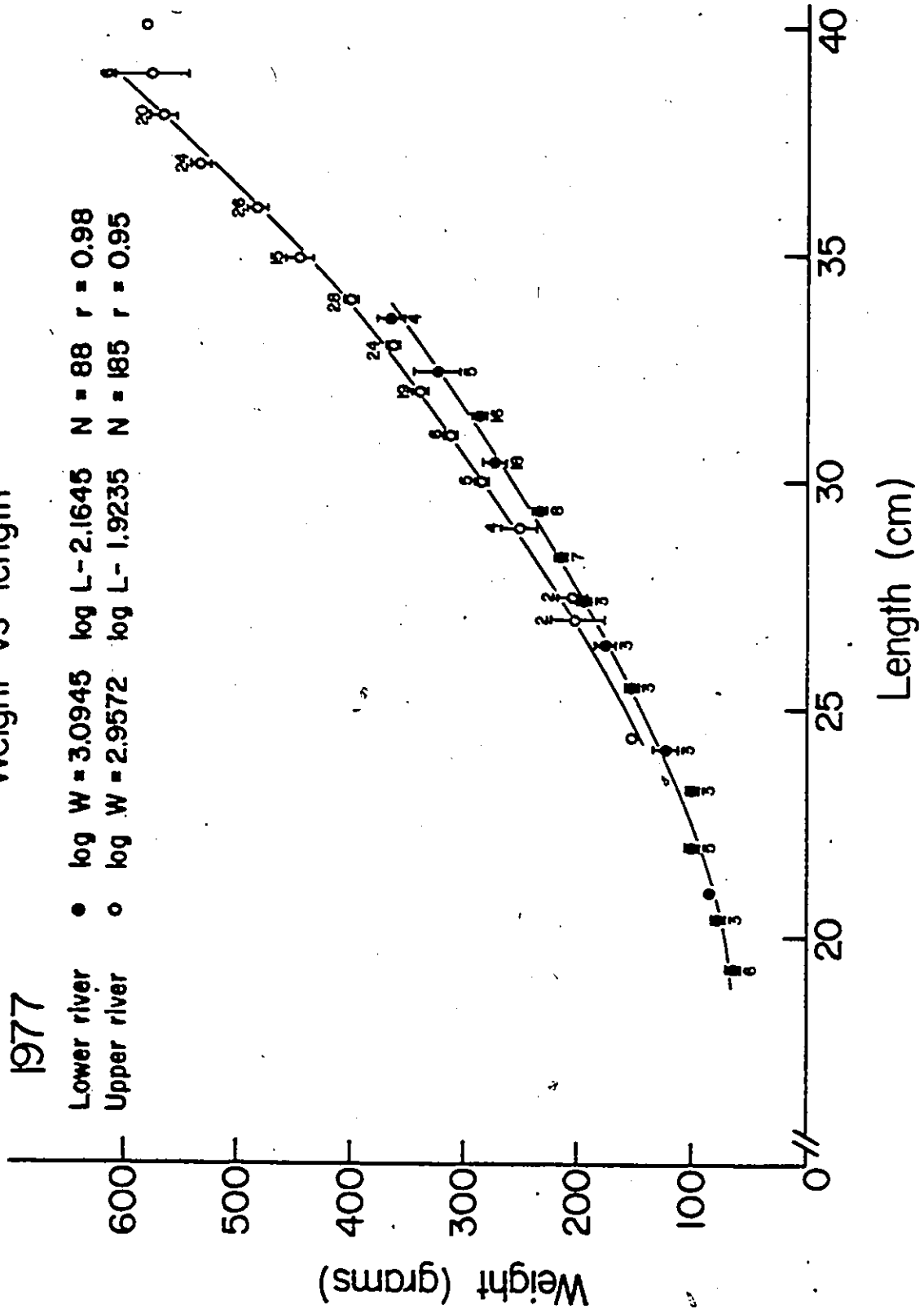


Fig. 13. Weight-total length relationship of mooneye collected from the lower and upper Ottawa River in 1977. The mean, standard errors, and number of specimens on bars are shown.

# Weight - vs - length

1977

Lower river ● log W = 3.0945 log L = 2.1645 N = 88 r = 0.98  
 Upper river ○ log W = 2.9572 log L = 1.9235 N = 185 r = 0.95



understandable that condition factors calculated for mooneye in the upper Ottawa River are somewhat higher than those determined for lower Ottawa River mooneye (Table 9). Even though these are visually greater, significant differences are found only between four, five, and six year olds in the two areas.

Sexual differences were not evident with respect to condition factors. When sexes are pooled, condition factors increase with an increase in age. One year olds in the lower Ottawa River had a mean condition factor of 874.22 while for two year olds the mean condition factor was 907.42 and so on.

#### Relative growth

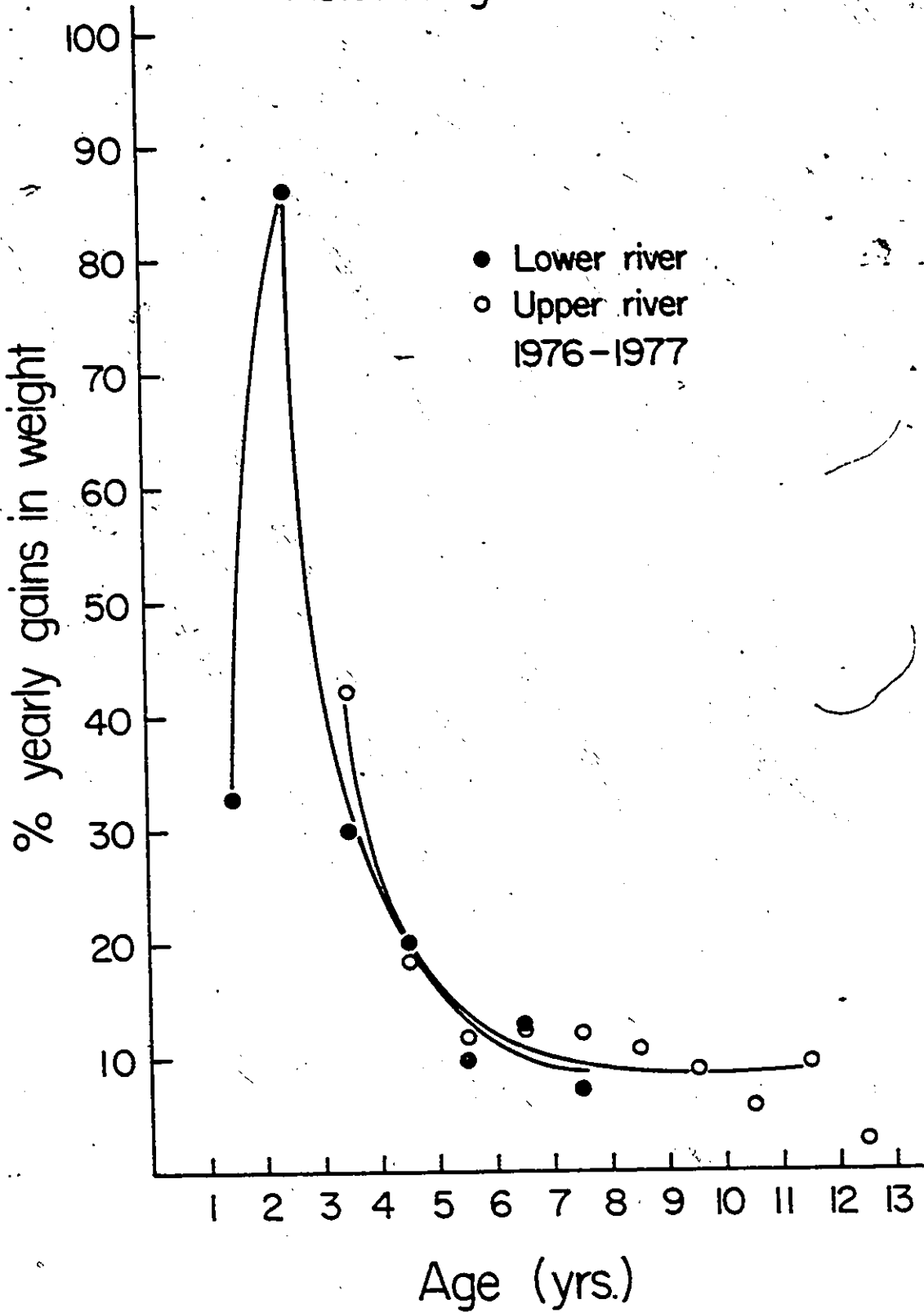
Relative growth, the amount of growth in percent weight, gained each year by mooneye, proved statistically insignificant for those ages common to both the lower and upper Ottawa River (Fig. 14). During their fourth year, mooneye in the lower and upper Ottawa River exhibited a 20.2 and 18.6 percent gain in weight respectively. Thus, the weight differences from one year to the next are similar in both areas. In analyzing the relative growth of mooneye, it is reasonable to assume that significant differences lie in the first three years of growth because significant differences ( $P \leq .05$ ) were noted in growth in the lower and upper Ottawa River in 1976 and 1977 with respect to total length and weight (Fig. 14). Data is not available for young fish in the upper Ottawa River.

Table 9. Fulton's mean condition factors of mooneye, sexes combined, in the lower and upper Ottawa River, 1976-1977.

Location	Age	Condition factor	Number of samples	95% Confidence limits
Lower Ottawa River	1+	874.22	3	823.66 - 924.78
	2+	907.42	16	864.01 - 950.83
	3+	931.83	9	903.40 - 960.26
	4+	941.23	23	910.29 - 972.17
	5+	946.80	48	919.77 - 973.83
	6+	938.33	63	915.54 - 961.12
	7+	983.06	25	925.40 - 1040.72
	8+	975.54	9	935.21 - 1015.87
Upper Ottawa River	3+	1023.63	4	859.34 - 1187.92
	4+	1030.58	11	983.50 - 1077.92
	5+	1023.03	22	991.41 - 1054.65
	6+	1014.57	39	989.09 - 1040.05
	7+	1039.67	39	1017.56 - 1061.78
	8+	1012.82	34	983.19 - 1042.45
	9+	1013.37	29	975.07 - 1051.67
	10+	1025.13	20	987.52 - 1062.74
	11+	1053.14	24	1023.81 - 1082.47
	12+	1122.01	7	1026.50 - 1217.52
	13+	1079.69	1	- -

Fig. 14. Relative growth of mooneye in the lower and upper Ottawa River in 1976 and 1977. The percent yearly gains in weight are represented by circles placed at the half-way mark between age groups.

# Relative growth



### Relationship between fork length and total length

Conversion of total length to fork length and vice versa is essential in growth studies so that other researchers can convert one length measurement to another, depending on their preference. The relationships between the two length measurements (cm) are:

$$T.L. = 1.1378 F.L. - 0.7948 \quad N = 160, \quad r = 0.996$$

$$F.L. = 0.8789 T.L. + 0.6985 \quad N = 160, \quad r = 0.996$$

### Walford plots and the von Bertalanffy equation

A few mooneye caught in the lower and upper Ottawa River had reached the ultimate total length ( $L_{\infty}$ ) described by the Walford plots (Fig. 15 and 16). However, the mathematical method of calculating  $L_{\infty}$  appears, from the literature, to be more acceptable. In this study, both methods gave identical asymptotic lengths.

To obtain the parameter  $t_0$ , the  $\ln(L_{\infty} - L_t)$  must be plotted against age. If both the estimate of  $L_{\infty}$  is accurate and the graph results in a straight line, the data conform to the von Bertalanffy equation (Everhart et al., 1975). The regressions for the above graphs are:

$$\text{lower Ottawa River} - \ln(L_{\infty} - L_t) = 3.4929 - 0.3679 t, \quad r = .999$$

$$\text{upper Ottawa River} - \ln(L_{\infty} - L_t) = 3.7394 - 0.2766 t, \quad r = .999$$

Thus, the von Bertalanffy equations for both areas are as follows:

41a

Fig. 15. Walford plot of mooneye caught in the lower Ottawa River during 1976 and 1977.

Lower river 1976-1977

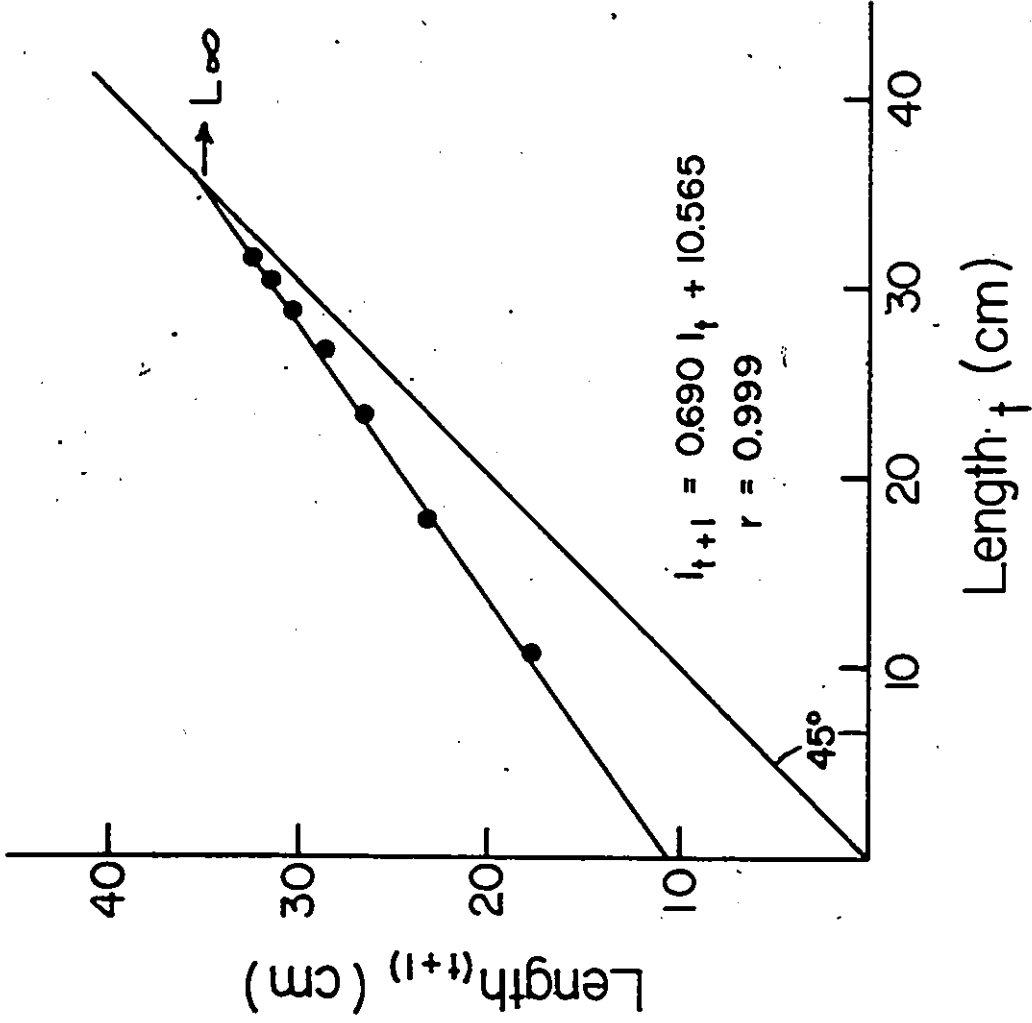
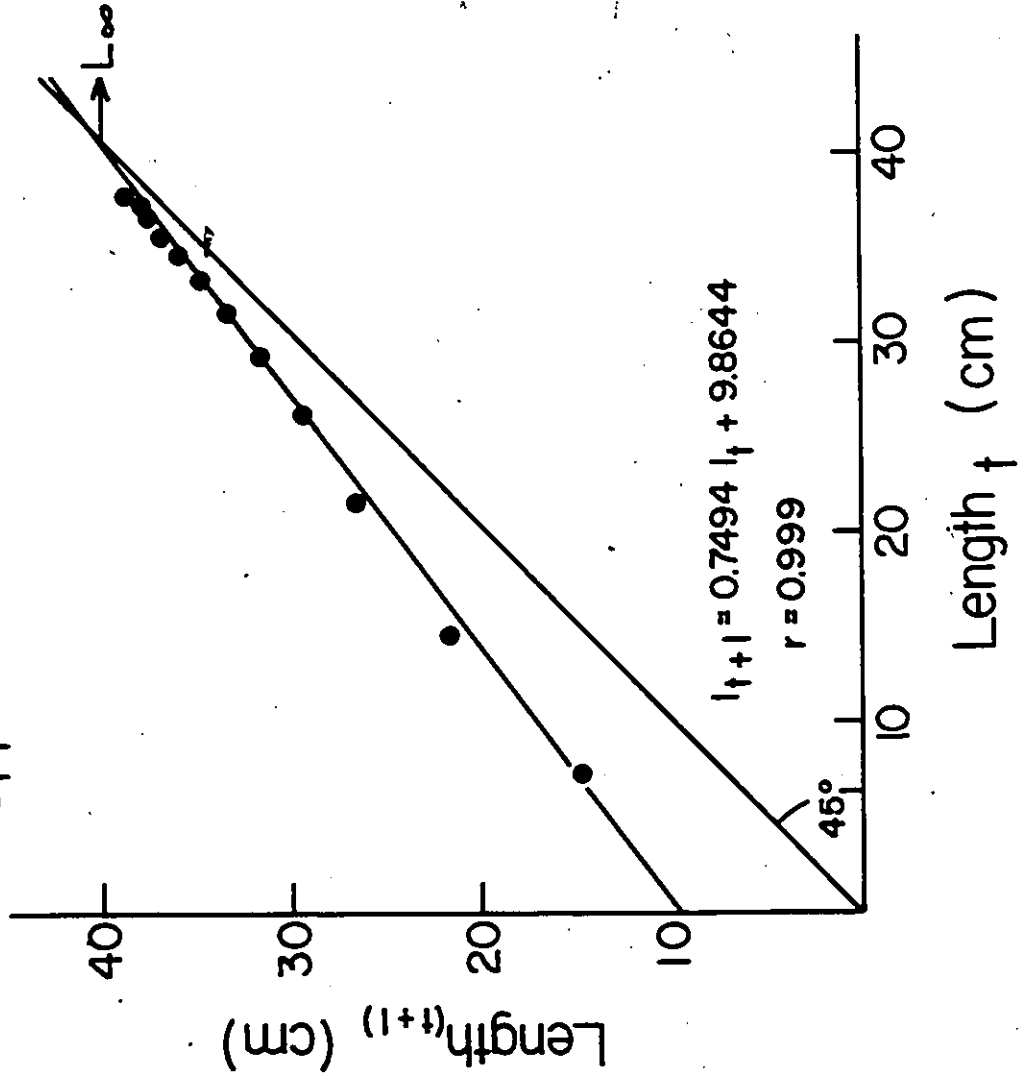


Fig. 16. Walford plot of mooneye caught in the upper Ottawa River during 1976 and 1977.

Upper river 1976-1977



lower Ottawa River -  $l_t = 34.1 (1 - e^{-0.3711(t + 0.1001)})$

upper Ottawa River -  $l_t = 39.4 (1 - e^{-0.2885(t - 0.2405)})$  -

When the total lengths at a certain age are computed using the above equations, values obtained are very similar to those found in the field.

## Food Habits

### Numerical method

Stomach content analysis was done for 160 and 233 fish from the lower and upper Ottawa River respectively, of which 7 and 13 stomachs were empty. Mooneye primarily eat aquatic insect larvae and nymphs, emergent adults, and adult ~~terrestrial~~ insects. The type, preference and number of insects consumed by mooneye vary from month to month (Tables 10 to 13).

The most prominent insect consumed in the lower Ottawa River in July of 1976 was the caddisfly (Table 10). Approximately 108 of them were eaten by each of the 67 mooneye caught in June. In decreasing order of consumption are the mayflies (28.94), flying ants (15.30), flies (15.26), beetles (6.45) which were all taken in June. Any organisms found less than twice are not discussed. One Coleoptera was found in the only fish caught in July. Of the three mooneye caught in August, an average of 123.33 Ephemeroptera, five Coleoptera, and three Tricoptera were found in their stomachs.

In the upper Ottawa River in July of 1976, the 36 fish caught were found to have consumed approximately 31 Ephemeroptera and eight Coleoptera per fish (Table 11). In August, Ephemeroptera were again the major insect species consumed.

Table 10. Average number of food items per fish taken each month in the lower Ottawa River, 1976.

Food item	Number of specimens (number with empty stomachs)		
	June 69 (3)	July 1 (0)	August 3 (0)
Pelecypoda	.03	-	-
Arachnida	.03	-	-
Crustacea			
Ostracoda	.04	-	-
Amphipoda	.04	-	-
Insecta			
Ephemeroptera	28.94	-	128.33
Odonata	.55	-	-
Zygoptera	-	-	-
Orthoptera	-	-	-
Plecoptera	1.30	-	-
Hemiptera	.19	-	-
Homoptera	.01	-	-
Coleoptera	6.45	1	5.00
Tricoptera	108.36	-	3.00
Diptera	15.26	-	-
Hymenoptera	.65	-	-
Formicidae	15.30	-	-
Minnows	.04	-	-

Table 11. Average number of food items per fish taken each month in the upper Ottawa River, 1976.

Food item	Number of specimens (number with empty stomachs)	
	July 36 (0)	August 11 (1)
Pelecypoda	-	-
Arachnida	-	-
Crustacea		
Ostracoda	-	-
Amphipoda	-	-
Insecta		
Ephemeroptera	30.67	9.55
Odonata	.22	-
Zygoptera	2.19	-
Orthoptera	-	-
Plecoptera	.11	-
Hemiptera	-	-
Homoptera	3.53	.27
Coleoptera	7.69	1.18
Tricoptera	2.44	1.27
Diptera	2.44	.64
Hymenoptera	.28	-
Formicidae	.75	-
Minnows	-	-

Ephemeroptera were also found in fairly large numbers during May through August in the lower Ottawa River, 1977 (Table 12). In May, June and July, Diptera composed the main part of the fish's diet with 8.45, 74.25, and 30.33 Diptera consumed in each month respectively. May appears to be the most diversified month with respect to mooneye consumption of insects. Tricoptera (14.76), Hymenoptera and Formicidae (13.39) and Coleoptera (11.12) were also consumed in May.

During the summer of 1977 in the upper Ottawa River, the main organisms taken each month were Ephemeroptera, Diptera, and Coleoptera (Table 13). Hymenoptera were important food items in June but not in the subsequent three months.

Histograms were constructed using the six most common groups of insects found in mooneye stomachs, whereby the percent of organisms consumed was plotted against age and also against total fish length intervals. Even though there is a small number of specimens and a lack of fish samples for some summer months, the histograms were constructed to get an indication of types and quantities of insects consumed at various ages and lengths.

Tricoptera were taken in large numbers (53.69 - 69.95 percent) for all age groups caught in the lower Ottawa River 1976, except for age seven where they only comprised 17.34 percent of the total number of organisms consumed for that specific age group (Fig. 17). This trend is reversed for Ephemeroptera. The range of percentages of Ephemeroptera for four to eight year old fish varies from 5.53 to 54.92 percent with the latter percentage pertaining to seven year olds.

Table 12. Average number of food items per fish taken each month in the lower Ottawa River, 1977.

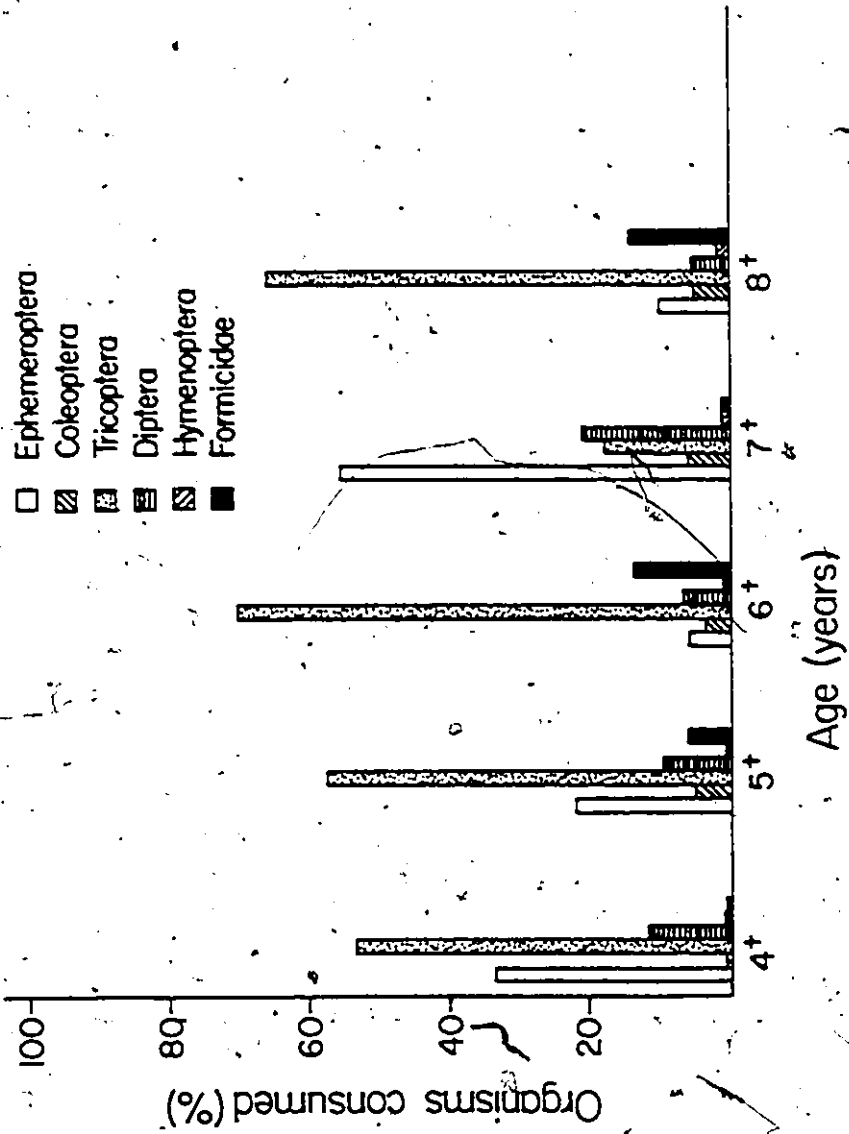
Food item	Number of specimens (number of empty stomachs)			
	May	June	July	August
	33 (3)	28 (0)	9 (0)	17 (1)
Pelecypoda	-	-	-	-
Arachnida	-	-	-	-
Crustacea				
Ostracoda	-	-	-	-
Amphipoda	-	-	-	-
Insecta				
Ephemeroptera	14.82	14.68	11.22	125.94
Odonata	-	-	-	-
Zygoptera	.12	.61	1.22	-
Orthoptera	.12	-	-	.12
Plecoptera	.30	.04	-	-
Hemiptera	-	-	-	-
Homoptera	-	.07	3.00	-
Coleoptera	11.12	1.96	3.11	.24
Tricoptera	14.76	-	.33	-
Diptera	8.45	74.25	30.33	.71
Hymenoptera	9.48	-	-	-
Formicidae	3.91	-	.22	-
Minnows	.03	.14	-	-

Table 13. Average number of food items per fish taken each month in the upper Ottawa River, 1977.

Food item	Number of specimens (number with empty stomachs)			
	June 15 (0)	July 122 (5)	August 46 (7)	September 3 (0)
Pelecypoda	-	-	-	-
Arachnida	-	-	-	.33
Crustacea				
Ostracoda	-	-	-	-
Amphipoda	-	-	.06	-
Insecta				
Ephemeroptera	16.67	6.79	6.06	-
Odonata	-	-	-	-
Zygoptera	-	.41	.02	-
Orthoptera	.07	.17	.66	-
Plecoptera	-	.08	-	-
Hemiptera	-	-	-	-
Homoptera	-	.24	.30	.33
Coleoptera	6.20	3.10	3.30	.33
Tricoptera	-	.29	-	-
Diptera	10.80	16.33	5.55	45.33
Hymenoptera	5.20	.50	.96	.33
Formicidae	-	1.28	1.47	-
Minnows	-	.008	.04	.33

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Fig. 17. The six most common food items found (percent) in mooneye stomachs at various ages in the lower Ottawa River during June, July, and August, 1976.



The intake of Diptera ranged from 4.26 to 20.38 percent, while that of Formicidae ranged from 0.38 to 13.97 percent in five to eight year olds. Coleoptera and Hymenoptera were present in very small amounts.

Ephemeroptera are found in significant numbers in fish ranging from five to eleven years old in the upper Ottawa River, 1976 (Fig. 18). There are no Ephemeroptera in four year old mooneye, while in 12 year olds, Ephemeroptera comprise 19.23 percent of the total number of insect intake, with 57.69 percent of the latter being Coleoptera. Tricoptera comprise 50 percent of the total number of insects consumed in four year olds and 19.23 percent in 12 year olds.

In the lower Ottawa River, 1977, a variety of insects were consumed in large numbers (Fig. 19). Ephemeroptera (3.84 to 79.46 percent) and Diptera (8.51 to 93.03 percent) were present in all age groups. Mooneye ate Formicidae, Tricoptera, and Hymenoptera in trace amounts (less than 7.14 percent) except for ages four (10.32 percent), six (17.94 percent), and eight (69.49 percent), respectively.

Ephemeroptera, Coleoptera, and Diptera dominated the intake of food in the upper Ottawa River, 1977 (Fig. 20). Formicidae were consumed in larger quantities at ages seven and eight (15.41 and 9.47 percent, respectively) than any other age groups.

The difficulty in interpreting these histograms arises from the fact that there is no indication of time, in terms of months, at which the number of mooneye at each age group was caught. To overcome this, four appendices were tabled with the appropriate information (Appendices 1 to 4): Generally, the type and number of insects consumed varies with the availability of the organisms in the field

51a

Fig. 18. The six most common food items found (percent) in mooneye stomachs at various ages in the upper Ottawa River during July and August, 1976.

- Ephemeroptera
- ▨ Coleoptera
- ▩ Tricoptera
- ▧ Diptera
- ▦ Hymenoptera
- Formicidae

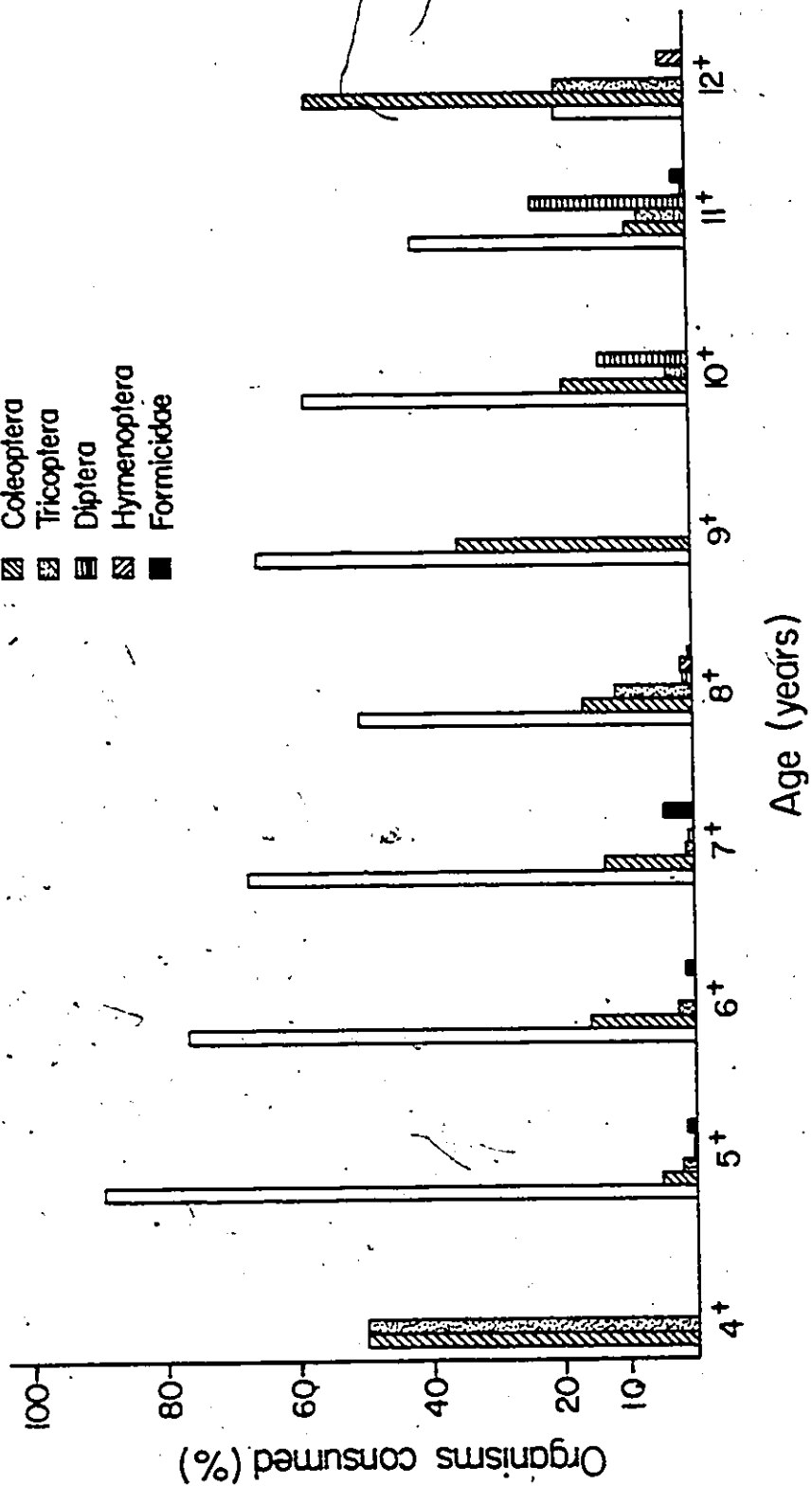


Fig. 19. The six most common food items found (percent) in mooneye stomachs at various ages in the lower Ottawa River during May, June, July, and August, 1977.

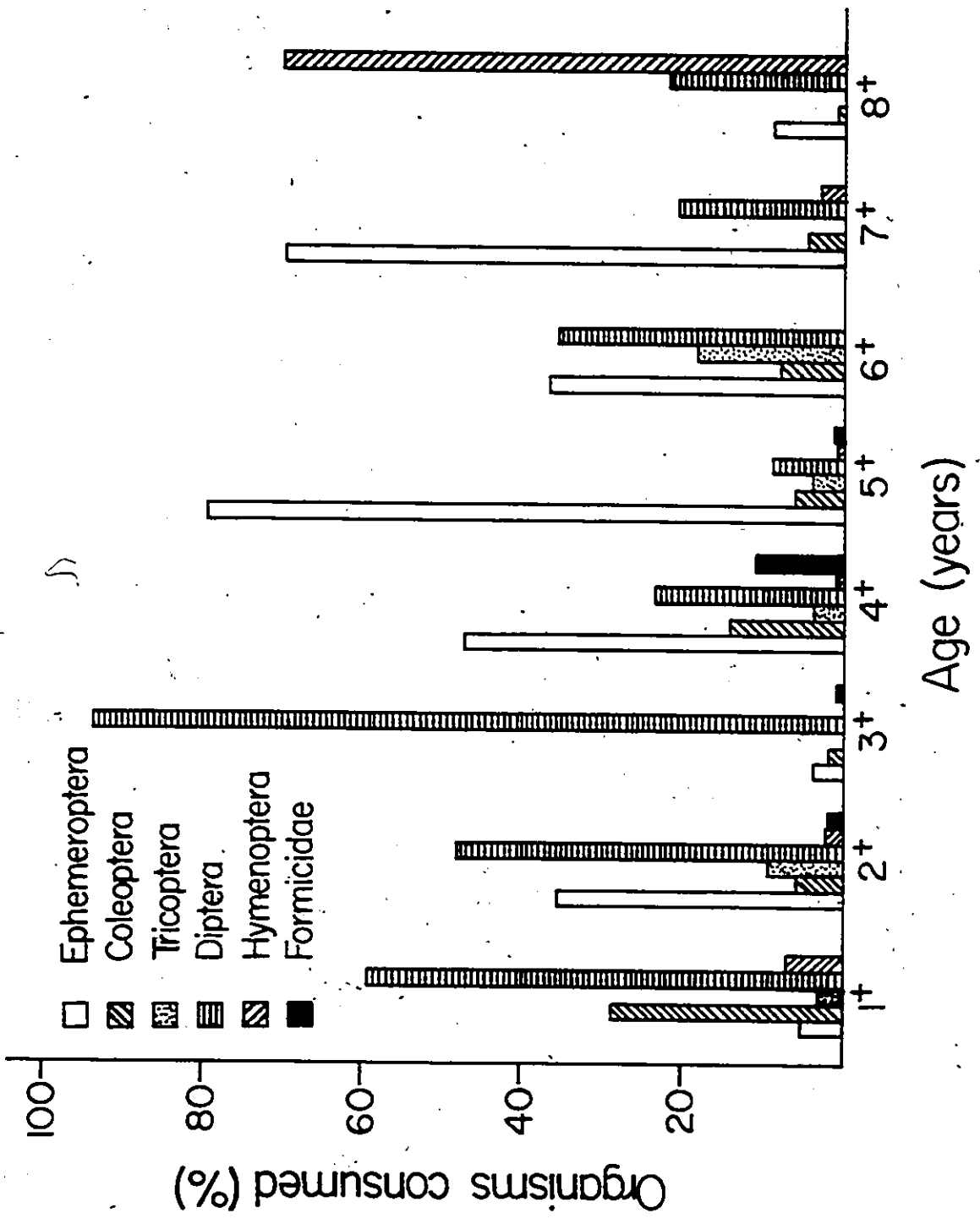
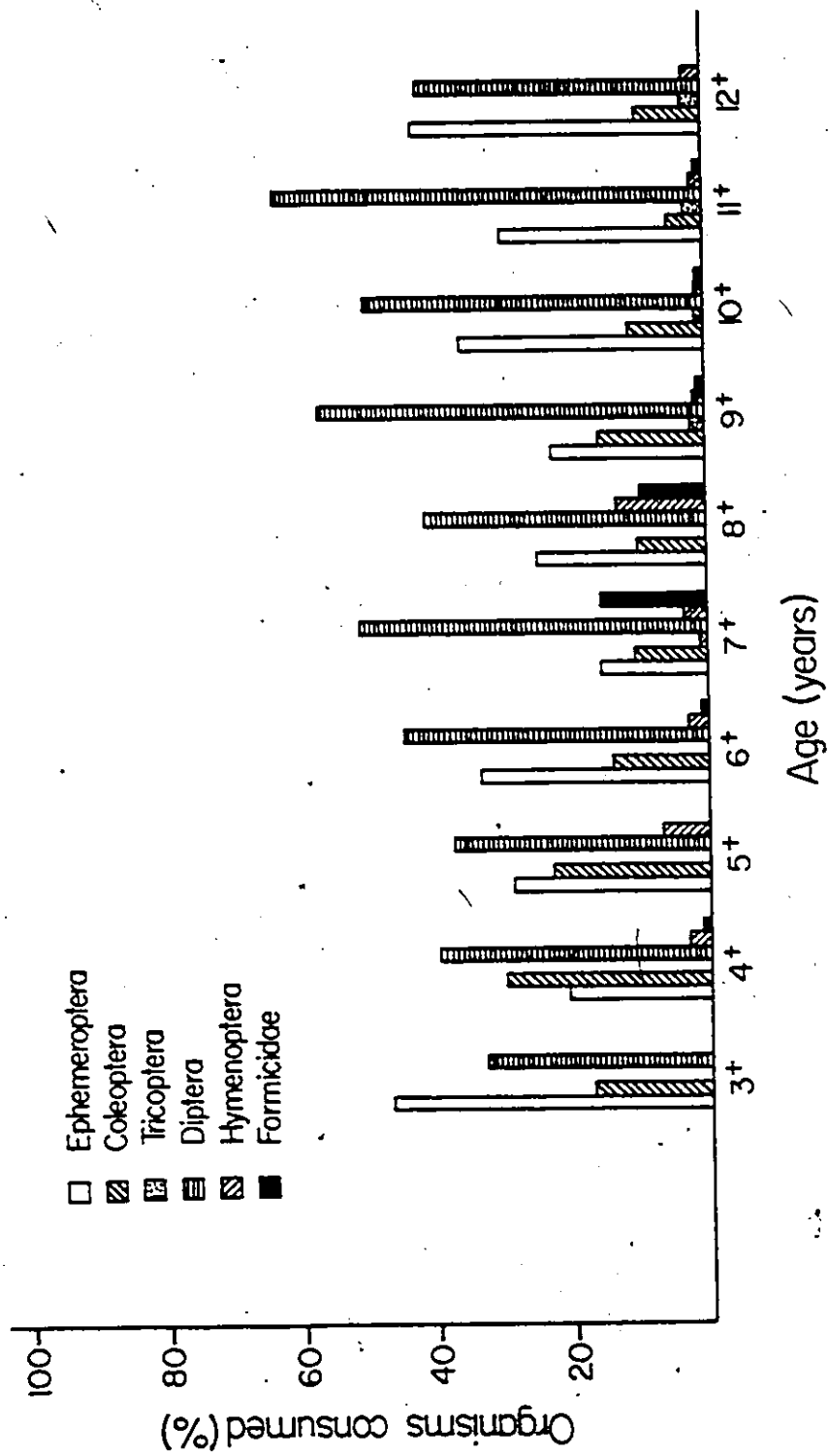


Fig. 20. The six most common food items found (percent) in mooneye stomachs at various ages in the upper Ottawa River during June, July, August, and September, 1977.



(Mackie, 1971).

The percentage of food items consumed at various total length intervals in the lower and upper Ottawa River in 1976 and 1977 were also constructed (Fig. 21 to 24). The same trends in eating habits are apparent here as they were in the four previous histograms (Fig. 17 to 20). This is expected as the younger fish are of smaller total length than older fish which are of longer total length.

Tricoptera were an important food item in all total length intervals with Ephemeroptera being almost as important for the 20-25 cm group of mooneye in the lower Ottawa River, 1976 (Fig. 21). In the upper Ottawa River, 1976, Ephemeroptera comprised 79.87, 57.03, and 16.67 percent of the total diets for each respective total length interval in increasing order (Fig. 22). Diptera (48.33 percent) was a major food item consumed at the 35-40 cm total length interval.

Diptera are prominent (97.26 percent) at the 15-20 cm total length interval in the lower Ottawa River, 1977 (Fig. 23). Fish in the 20-30 cm category ate mostly Ephemeroptera (approximately 57 percent of total) while those in the 30-35 cm total length interval consumed Hymenoptera in large quantities (58.57 percent).

In the upper Ottawa River, 1977, Ephemeroptera, Coleoptera, and Diptera formed the main source of food in the diets of mooneye (Fig. 24). In all histograms, the occurrence of various insects in the field coincides with the intake of those organisms by mooneye in the Ottawa River.

Fig. 21. The six most common food items found (percent) in mooneye stomachs at various fish lengths in the lower Ottawa River during June, July and August, 1976.

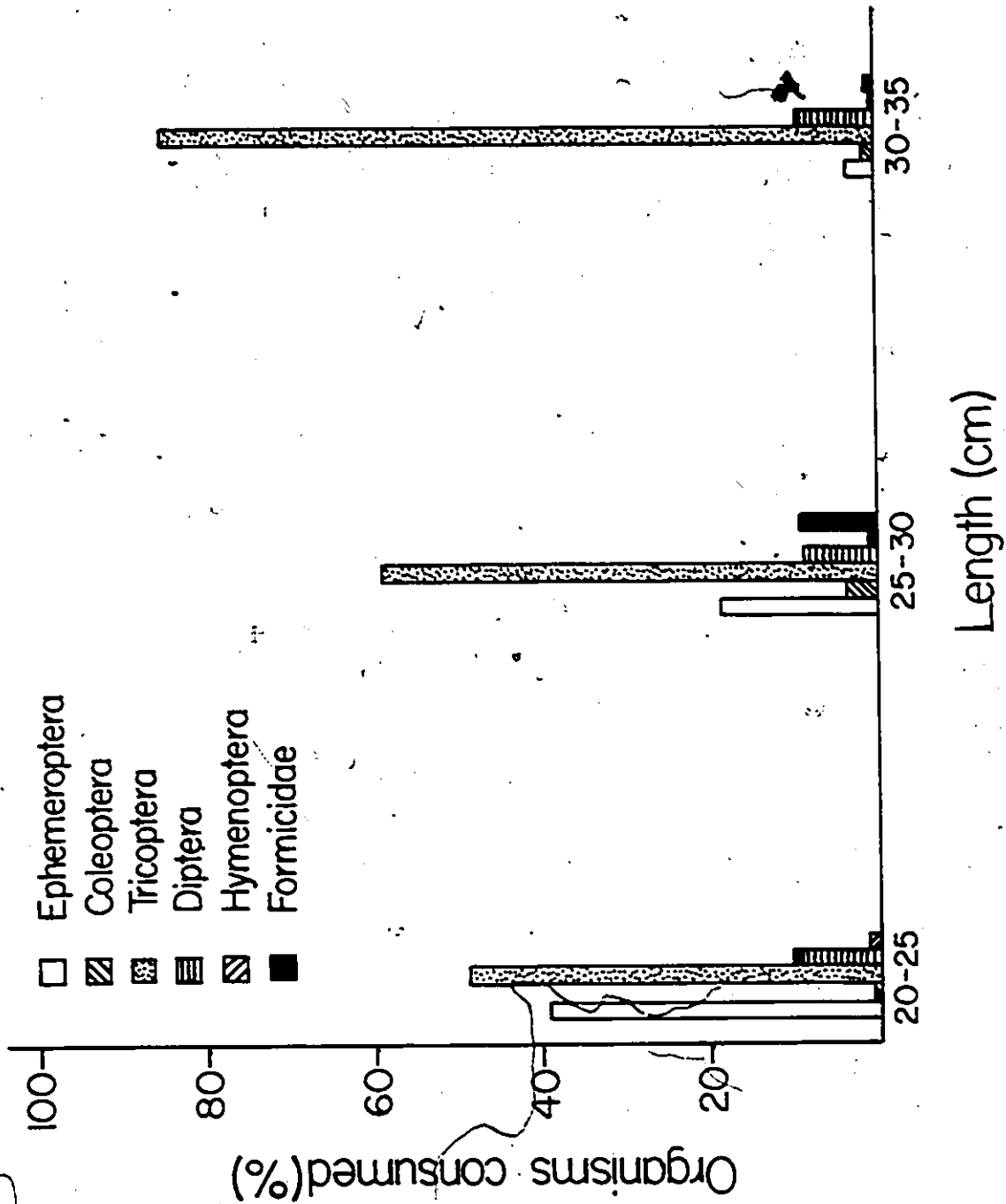


Fig. 22. The six most common food items found (percent) in mooneye stomachs at various fish lengths in the upper Ottawa River during July and August, 1976.

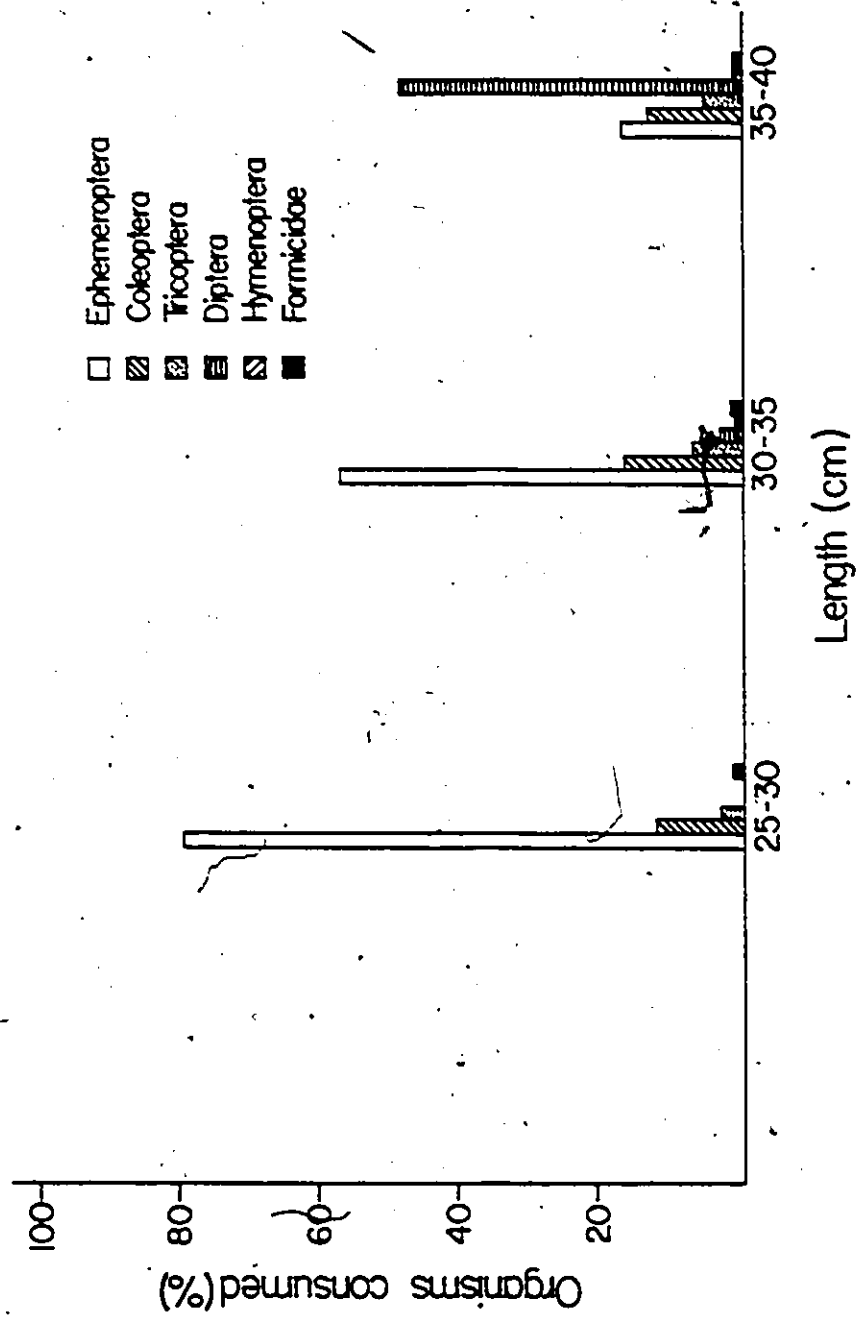


Fig. 23. The six most common food items found (percent) in mooneye stomachs at various fish lengths in the lower Ottawa River during May, June, July, and August, 1977.

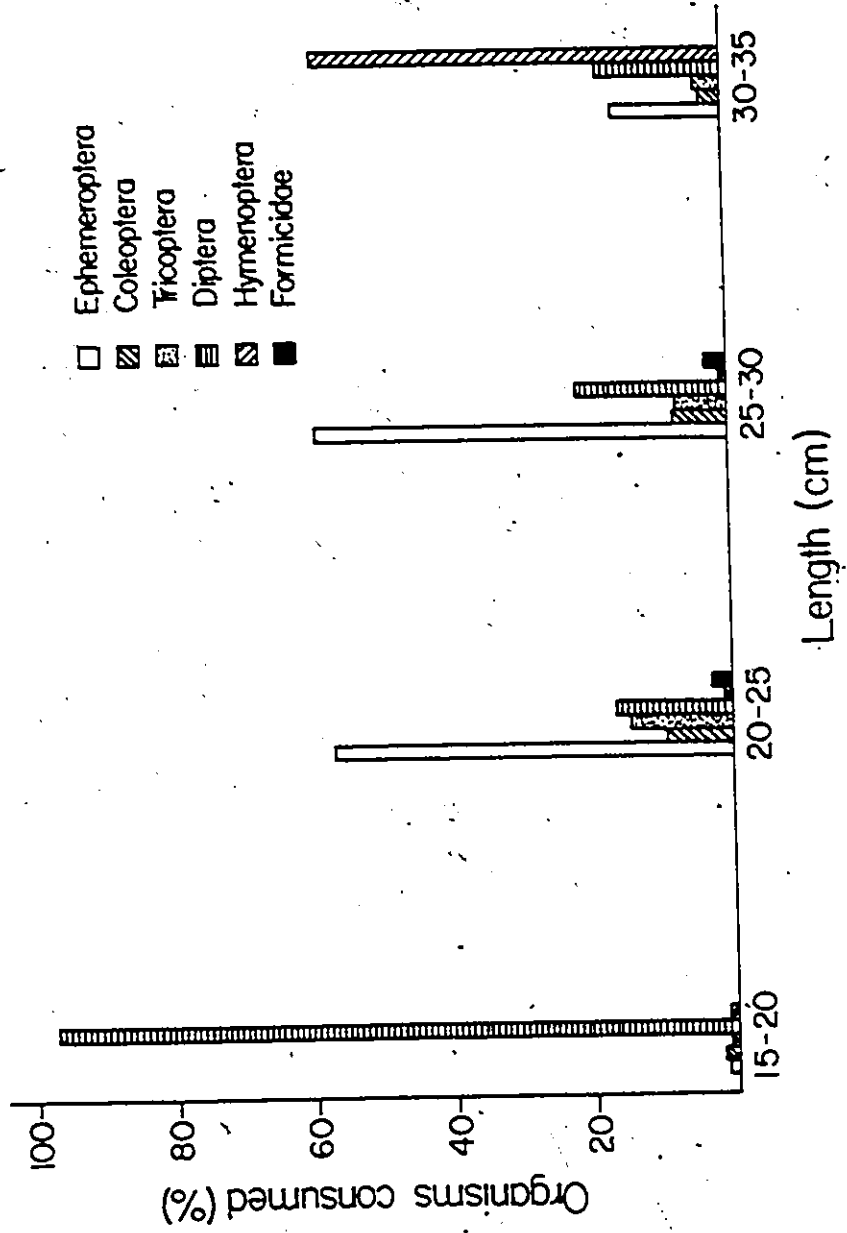
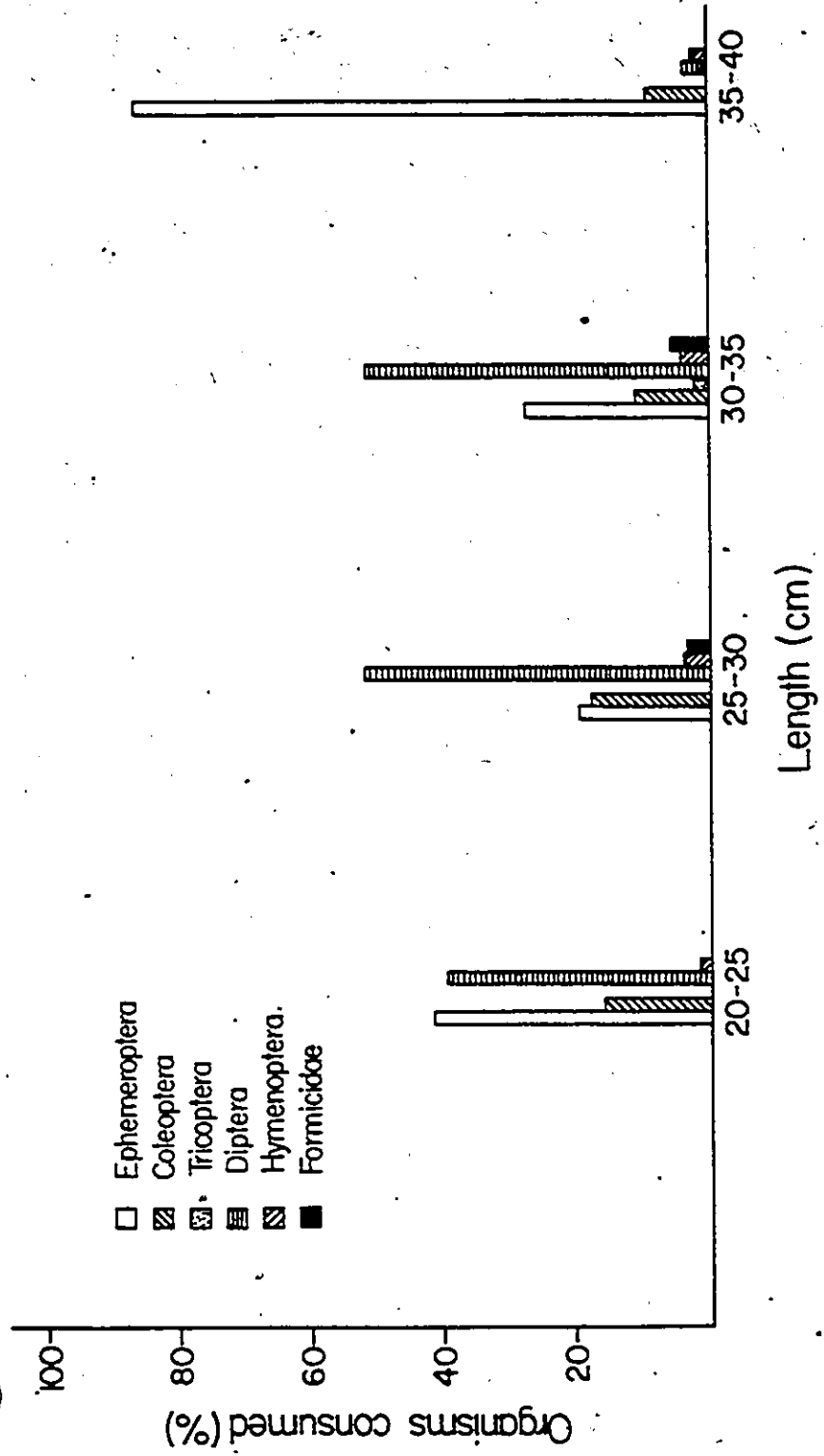


Fig. 24. The six most common food items found (percent) in mooneye stomachs at various fish lengths in the upper Ottawa River during June, July, August, and September, 1977.



### Frequency of occurrence

Each kind of food item may occur in a number of fish at each age. This occurrence is expressed as a percentage of the total number of specimens (Tables 14 to 17).

In the lower Ottawa River, 1976, Ephemeroptera, Trichoptera, and Diptera each occur in over 50 percent of the fish caught from ages four to eight (Table 14). Coleoptera also occur in over 50 percent of the stomachs analyzed in fish ranging five to eight years, while of the number of stomachs analyzed for four year olds, 30 percent contained Coleoptera. Most fish stomachs contained miscellaneous, composed of unidentified digested material.

In the upper Ottawa River, 1976, Ephemeroptera were found in 40 to 100 percent of fish stomachs at various years of age (Table 15). Coleoptera were found in more than 66 percent of the stomachs examined. Trichoptera were found in all stomachs in ages four to 12 and varied from 25 to 60 percent occurrence in ages five to 11. All stomachs except 11.11 percent of those at age 11 had decomposed material.

Ephemeroptera occurred in at least one third of all age groups examined for stomach contents and was found in as many as two thirds of the stomachs of seven year old fish caught in the lower Ottawa River, 1977 (Table 16). Coleoptera and Diptera were found in all one year olds and varied in all other age groups.

Over 50 percent of all age groups contained Ephemeroptera and Diptera in the upper Ottawa River, 1977 (Table 17). Forty-one to 81.82 percent of stomachs contained Coleoptera. Less than 33 percent of stomachs contained Zygoptera, Plecoptera, Homoptera, Trichoptera,



Table 15. Percent occurrence of food items for each year class of mooneye in the upper Ottawa River, 1976.

Food items	Year class											
	4	5	6	7	8	9	10	11	12	Percent occurrence		
Number of stomachs	1	5	5	9	9	3	4	9	2			
Percent of empty stomachs	0	0	0	0	0	0	0	11.11	0			
Pelecypoda	-	-	-	-	-	-	-	-	-			
Arachnida	-	-	-	-	-	-	-	-	-			
Crustacea	-	-	-	-	-	-	-	-	-			
Ostracoda	-	-	-	-	-	-	-	-	-			
Amphipoda	-	-	-	-	-	-	-	-	-			
Insecta	-	-	-	-	-	-	-	-	-			
Ephemeroptera	-	40.00	80.00	77.78	77.78	66.67	100.00	44.44	50.00			
Odonata	-	-	20.00	33.33	11.11	-	-	-	-			
Zygoptera	-	-	20.00	22.22	55.56	-	50.00	33.33	-			
Orthoptera	-	20.00	-	-	22.22	-	-	-	-			
Plecoptera	-	-	-	-	-	-	-	-	-			
Hemiptera	-	-	-	-	-	-	-	-	-			
Homoptera	-	20.00	40.00	66.67	66.67	-	50.00	33.33	-			
Coleoptera	100.00	100.00	80.00	77.78	77.78	66.67	100.00	77.78	100.00			
Tricoptera	100.00	60.00	40.00	33.33	55.56	-	25.00	33.33	100.00			
Diptera	-	-	-	11.11	33.33	-	50.00	22.22	-			
Hymenoptera	-	-	-	-	22.22	-	-	-	50.00			
Formicidae	-	40.00	40.00	66.67	11.11	-	-	33.33	-			
Minnows	-	-	-	-	-	-	-	-	-			
Miscellaneous	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.89	100.00			

Table 16. Percent occurrence of food items for each year class of mooneye in the lower Ottawa River, 1977.

Food items	Year class							
	1	2	3	4	5	6	7	8
Number of stomachs	3	15	8	13	18	18	9	3
Percent of empty stomachs	0	0	0	0	5.56	5.56	11.11	0
	Percent occurrence							
Pelecypoda	-	-	-	-	-	-	-	-
Arachnida	-	-	-	-	-	-	-	-
Crustacea	-	-	-	-	-	-	-	-
Ostracoda	-	-	-	-	-	-	-	-
Amphipoda	-	-	-	-	-	-	-	-
Insecta	33.3	46.7	87.5	46.15	50.00	55.55	66.67	33.33
Ephemeroptera	-	-	-	-	-	-	-	-
Odonata	-	-	-	-	-	-	-	-
Zygoptera	-	13.3	25.0	15.38	-	27.78	11.11	-
Orthoptera	-	-	-	15.38	5.56	-	-	33.33
Plecoptera	-	6.7	-	-	5.56	5.56	-	-
Hemiptera	-	-	-	-	-	-	-	-
Homoptera	-	6.7	37.5	-	5.56	11.11	-	-
Coleoptera	100.00	46.7	37.5	69.23	50.00	77.78	55.56	33.33
Tricoptera	33.3	20.0	-	7.69	16.67	22.22	-	-
Diptera	100.00	73.3	87.5	53.85	38.89	55.55	55.56	66.67
Hymenoptera	66.67	6.67	-	23.08	5.56	-	11.11	33.33
Formicidae	-	13.3	12.5	7.69	11.11	-	-	-
Minnows	-	-	12.5	-	-	-	11.11	-
Miscellaneous	100.00	100.00	100.00	100.00	94.44	94.44	88.89	100.00

Table 17. Percent occurrence of food items for each year class of mooneye in the upper Ottawa River, 1977.

Food item	Year class											
	3	4	5	6	7	8	9	10	11	12		
Number of stomachs	3	11	14	32	35	21	29	20	17	3		
Percent of empty stomachs	0	0	7	9	4.43	9.52	3.45	15	11.76	0		
	Percent occurrence											
Pelecypoda	-	-	-	-	-	-	-	-	-	-	-	-
Arachnida	-	-	-	-	-	-	3.45	-	-	-	-	-
Crustacea	-	-	-	-	-	-	-	-	-	-	-	-
Ostracoda	-	-	-	-	-	-	-	-	-	-	-	-
Amphipoda	-	-	-	-	-	-	3.45	-	-	-	-	-
Insecta	100.00	63.64	64.29	56.25	65.71	66.67	55.17	60.00	76.47	66.7		
Ephemeroptera	-	-	-	-	-	-	-	-	-	-	-	-
Odonata	-	-	-	-	-	-	-	-	-	-	-	-
Zygoptera	33.33	27.27	7.14	15.63	14.29	23.81	3.45	15.00	-	33.33		
Orthoptera	-	27.27	7.14	25.00	17.14	14.29	24.14	30.00	11.76	66.7		
Plecoptera	-	-	7.14	6.25	2.86	-	-	-	5.88	-		
Hemiptera	-	-	-	-	-	-	-	-	-	-	-	-
Homoptera	-	9.09	7.14	9.38	11.43	4.76	13.79	10.00	-	-	-	-
Coleoptera	66.67	81.82	50.00	68.75	71.43	76.19	75.86	55.00	41.18	66.7		
Tricoptera	-	-	-	-	2.86	-	6.90	5.00	5.88	33.33		
Diptera	100.00	63.64	64.29	65.63	68.57	57.14	68.97	70.00	52.94	100.00		
Hymenoptera	-	45.45	14.29	31.25	28.57	28.57	27.59	20.00	17.65	33.33		
Formicidae	-	9.09	-	6.25	14.29	4.76	6.90	10.00	-	-		
Minnows	-	-	-	3.13	-	-	10.34	-	-	-		
Miscellaneous	100.00	100.00	92.86	90.63	88.57	90.48	96.55	85.00	88.24	100.00		

Formicidae, and minnows.

#### Volumetric method

Food charts were constructed so as to get a better indication of what volume of food items was consumed by mooneye in both areas of the Ottawa River (Fig. 25 to 33). Since there were few specimens caught on a given date, and consequently few in each month during the study, lower and upper Ottawa River data on food contents will not be compared (Appendices 1 to 4).

Unidentifiable digested material was found in all age groups and varied from 29.9 to 95.24 percent of the total volume of food encountered in each age class. Food items found in trace amounts (less than 4.5 percent) will not be discussed.

In the lower Ottawa River, 1976, Ephemeroptera and Tricoptera comprised 18.62 and 35.54 percent respectively, of the total volume of food items found in four year old mooneye (Fig. 25). Similar percentages were found in five year olds in the lower Ottawa River, while 45.98 percent Ephemeroptera comprised most of the diet of five year olds in the upper Ottawa River.

Ephemeroptera and Tricoptera were the main items consumed by six year olds in the upper and lower Ottawa River respectively, in 1976 with percent volumes of 16.65 and 39.65 percent (Fig. 26). Ephemeroptera was the main food item for seven year olds in the upper Ottawa River while those in the lower Ottawa River consumed Diptera, Tricoptera, Coleoptera, and Ephemeroptera in the following percentages, 4.70, 11.22, 5.54, and 15.17 percent.

Fig. 25. Changes in stomach contents of four and five year old mooneye (percent volume) in the lower and upper Ottawa River, 1976.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

Changes in stomach contents of mooneye (Hiodon tergisus) for 1976.  
(% volume)

Upper river

Lower river

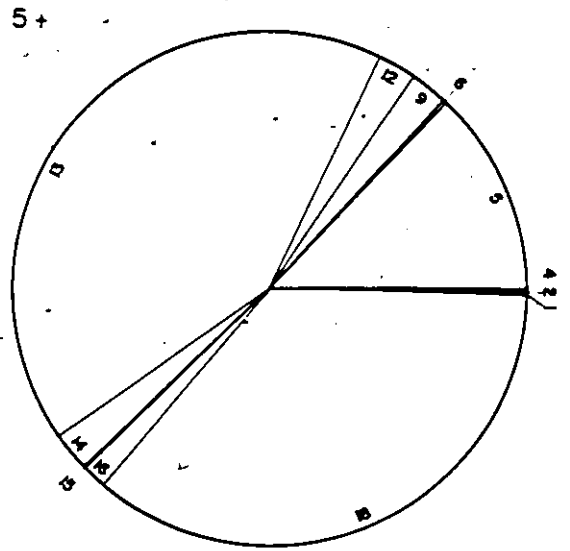
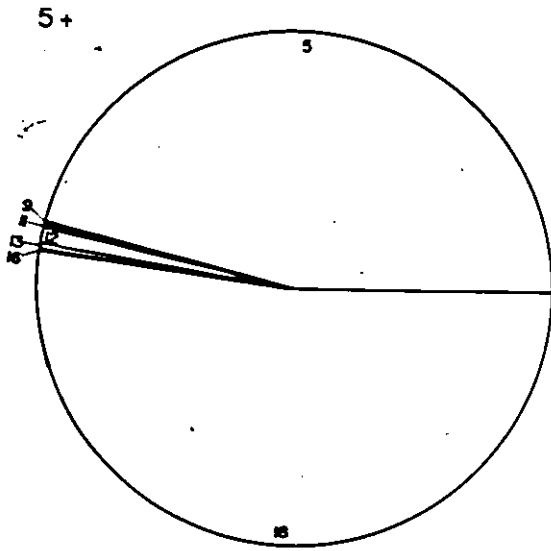
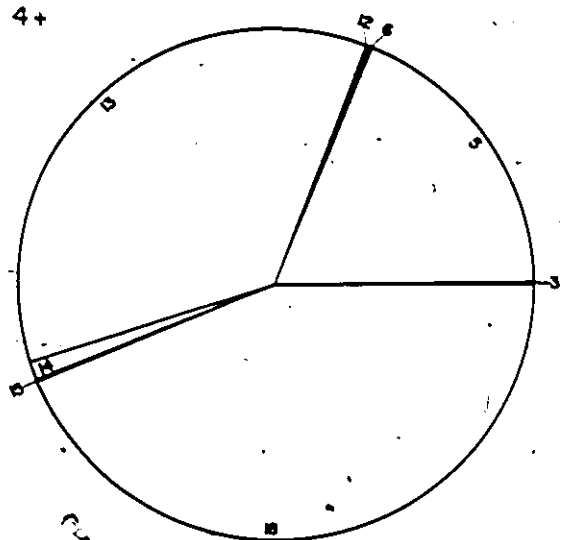
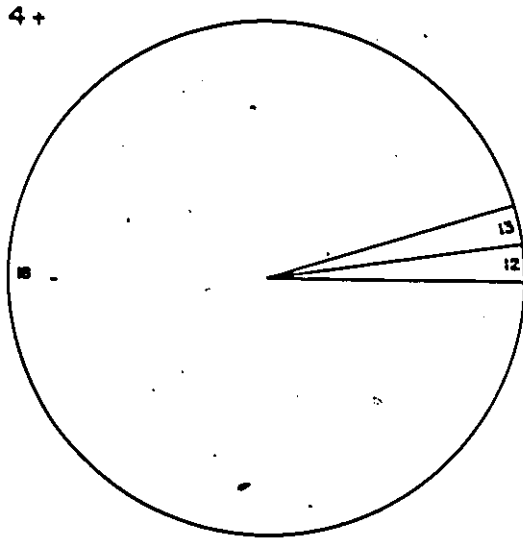


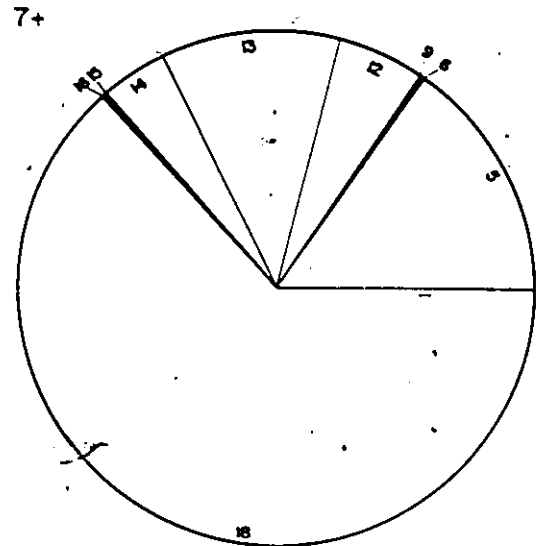
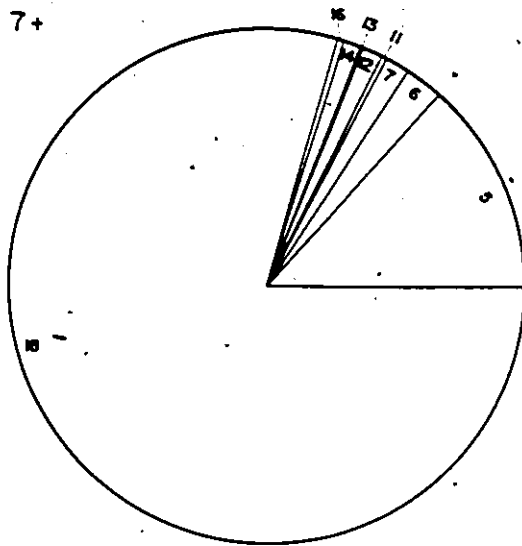
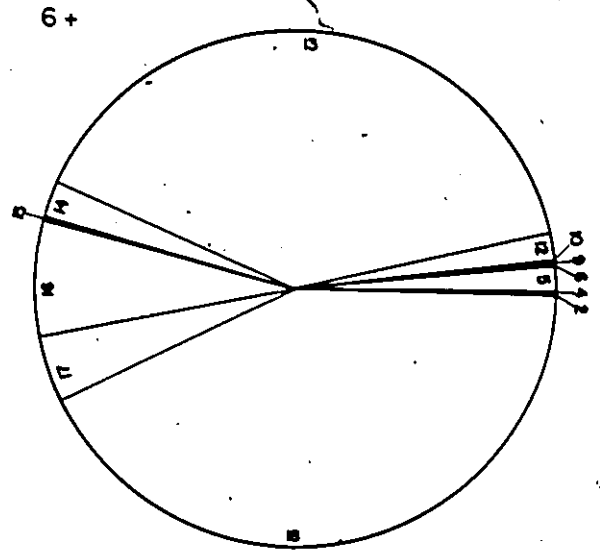
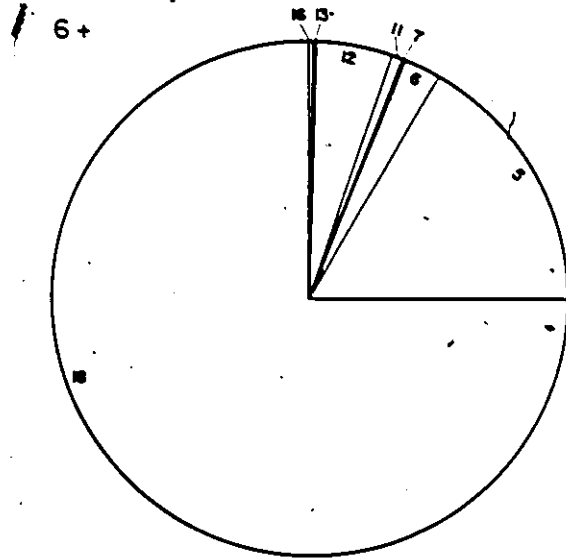
Fig. 26. Changes in stomach contents of six and seven year old mooneye (percent volume) in the lower and upper Ottawa River, 1976.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1976

Upper river

Lower river



9

Eight year olds in the lower and upper Ottawa River, 1976 ate a variety of food items with Tricoptera (37.30 percent) and Ephemeroptera (9.35 percent) being the most abundant respectively, when considering the total volume of ingested food (Fig. 27). Also encountered in eight year old lower Ottawa River mooneye were Formicidae (7.30 percent).

In the upper Ottawa River, 1976, nine and 10 year old mooneye consumed 41.79 and 9.55 percent Ephemeroptera respectively (Fig. 28). The only other identifiable food item consumed was Coleoptera (6.34 percent) for nine year old fish, while 10 year old fish ate a variety of other organisms. Various insects were consumed by 11 year olds with the total volume of Diptera (7.29 percent) and Ephemeroptera (8.99 percent) being of slightly larger volume than Formicidae, Tricoptera, Coleoptera, Homoptera, and Zygoptera ingested. Coleoptera composed 6.51 percent of the total volume of organisms consumed by 12 year olds.

One year old fish in the lower Ottawa River, 1977, consumed 11.07 percent Diptera and 12.80 percent Coleoptera (Fig. 29). In two year olds, Diptera comprised 32.0 percent of the total volume of food items consumed followed by Ephemeroptera (24.60 percent) and Tricoptera (10.90 percent), and trace volume (less than 4.5 percent) of Coleoptera, Plecoptera, Zygoptera, and Homoptera.

In the lower and upper Ottawa River, 1977, Diptera comprised 20.11 and 12.58 percent of the total intake by volume of three year olds respectively (Fig. 30). Also, in three year olds in the lower Ottawa River, 6.54 percent of the total ingested food was comprised of Ephemeroptera.

A larger variety of organisms was ingested by four year olds

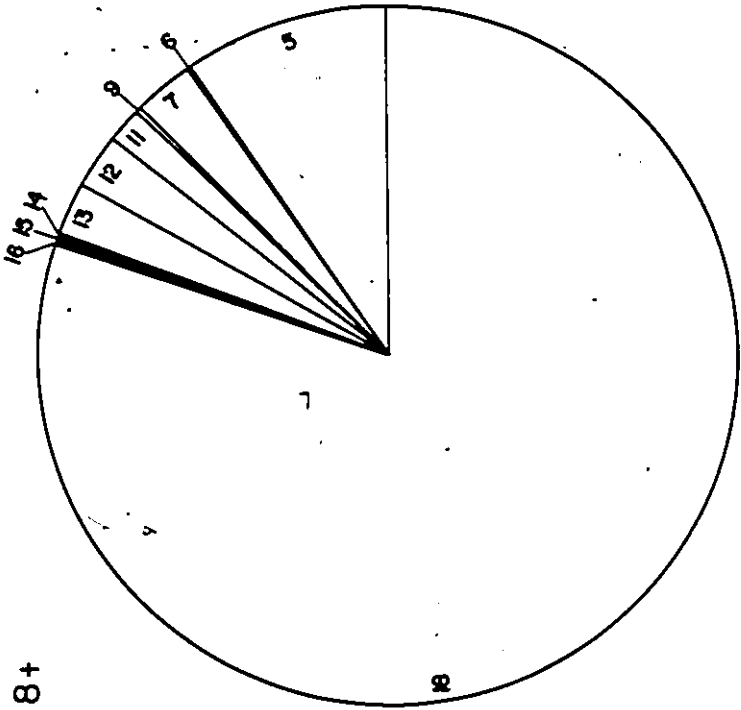
Fig. 27. Changes in stomach contents of eight year old mooneye (percent volume) in the lower and upper Ottawa River, 1976.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1976

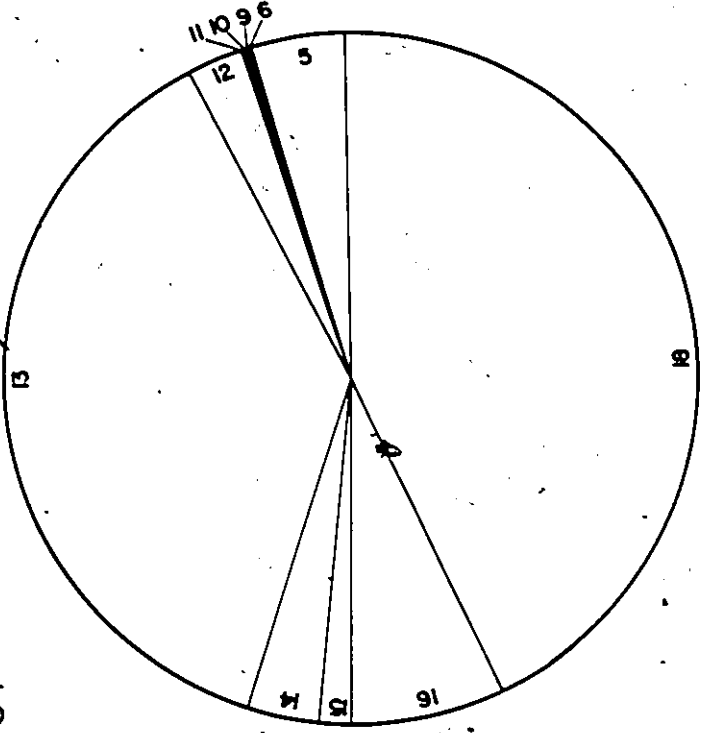
Upper river

Lower river



8+

8+



18

15

Fig. 28. Changes in stomach contents of nine, ten, eleven and twelve year old mooneye (percent volume) in the upper Ottawa River, 1976.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1976  
Upper river

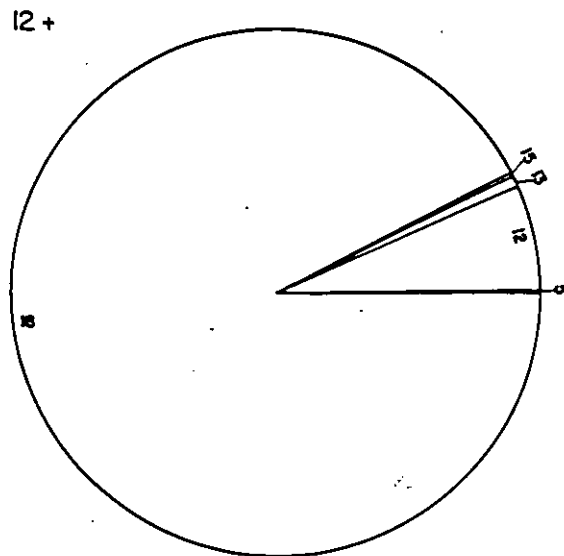
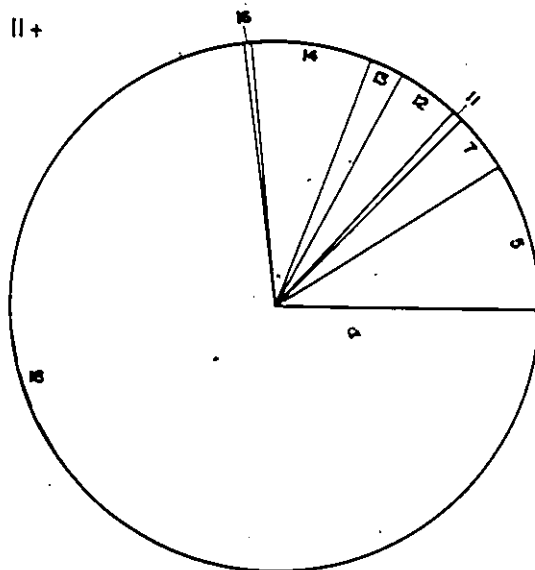
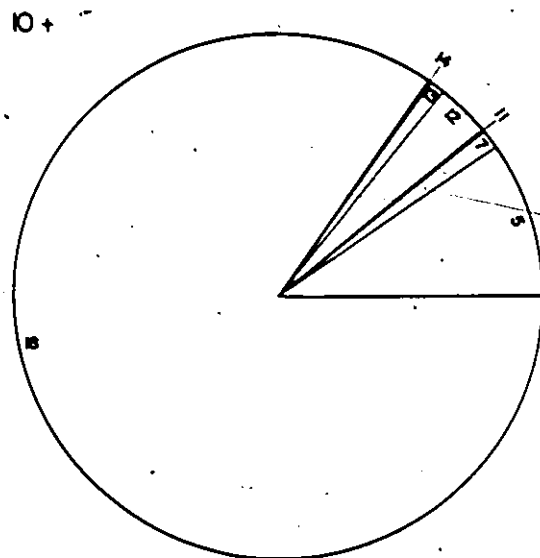
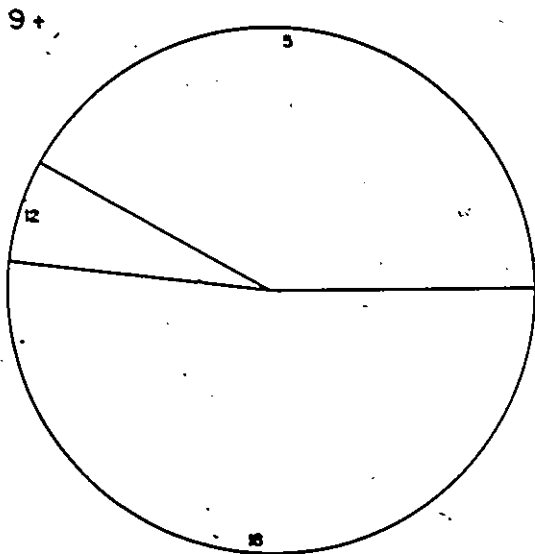


Fig. 29. Changes in stomach contents of one and two year old mooneye (percent volume) in the lower Ottawa River, 1977.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

Changes in stomach contents of mooneye (Hiodon tergisus) for 1977 (% volume)

Lower river

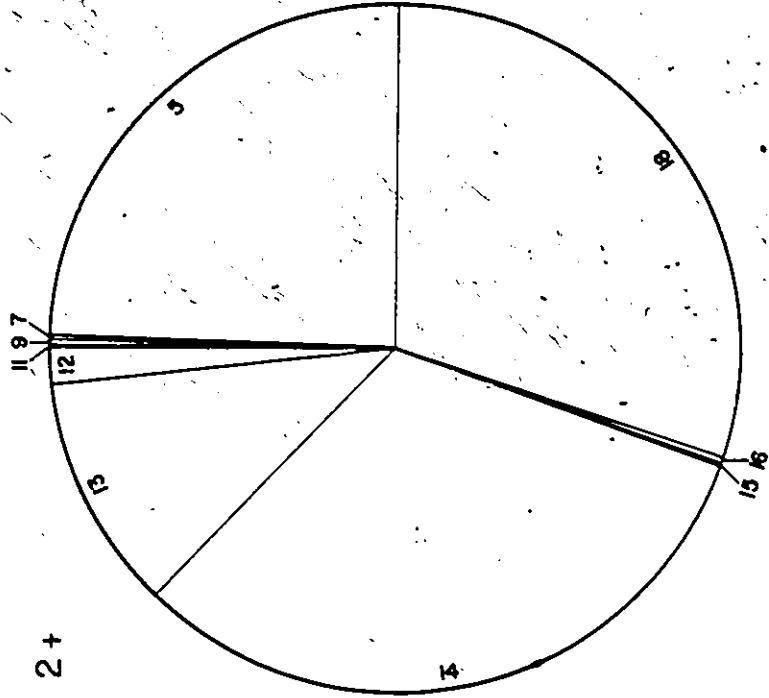
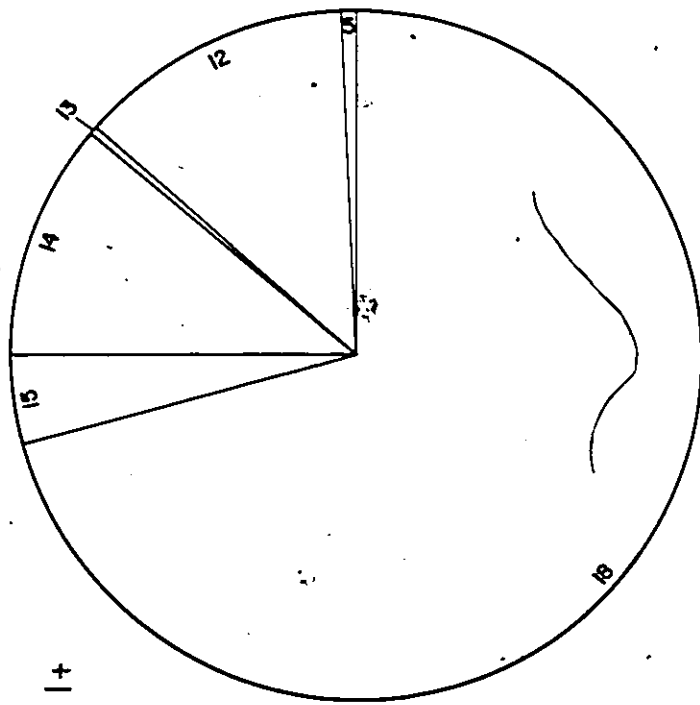


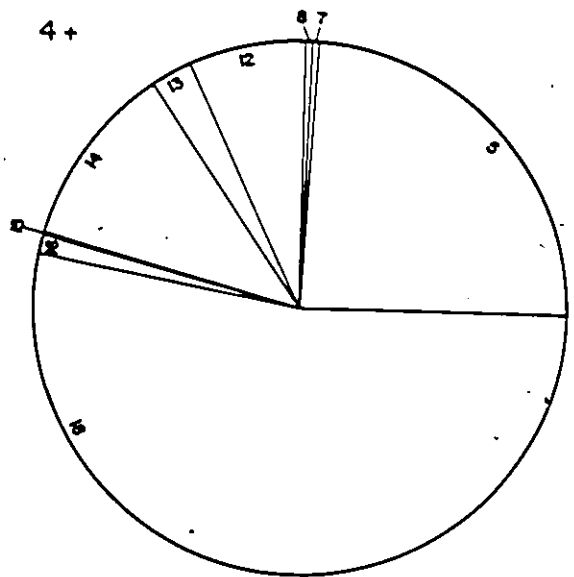
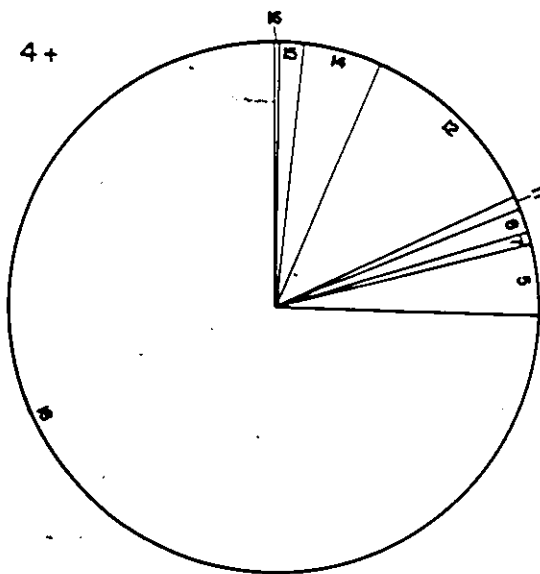
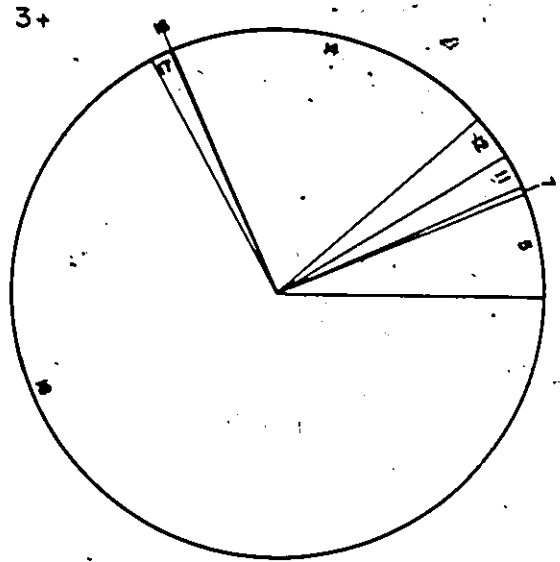
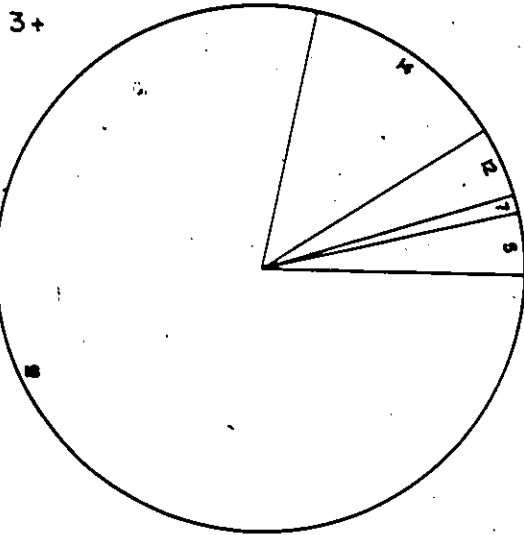
Fig. 30. Changes in stomach contents of three and four year old mooneye (percent volume) in the lower and upper Ottawa River, 1977.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1977

Upper river

Lower river



in both areas (Fig. 30). The most prominent of these being Coleoptera (11.52 percent) and Diptera (4.80 percent) in the upper Ottawa River, and Ephemeroptera (24.27 percent), Diptera (11.02 percent), and Coleoptera (7.04 percent) in the lower Ottawa River.

The largest volume of insects found in five year olds in the lower Ottawa River, 1977 was Ephemeroptera (36.55 percent), Coleoptera (4.72 percent), and Diptera (4.77 percent) (Fig. 31). Five year olds in the upper Ottawa River consumed Ephemeroptera (9.76 percent), Coleoptera (19.71 percent), and Diptera (5.27 percent). In the lower Ottawa River, six year old mooneye consumed 14.83, 14.44, 8.06, and 5.81 percent Ephemeroptera, Diptera, Tricoptera, and Coleoptera respectively, of the total volume of insects taken. Six year olds in the upper Ottawa River ate Ephemeroptera, Diptera, Coleoptera, and Orthoptera in the following decreasing volumes respectively: 9.79, 7.57, 6.95, and 5.07.

Diptera comprised 8.50 and 12.44 percent of the total food intake by seven year olds in the lower and upper Ottawa River respectively (Fig. 32). In addition, seven year olds' main diet was composed of 10 to 45 percent minnows, and 5.32 percent Ephemeroptera. In the upper Ottawa River, other important food items found were 5.77 percent Ephemeroptera and 4.97 percent Coleoptera.

In the lower Ottawa River, 1977 Hymenoptera (45.91 percent) and Diptera (12.72 percent) formed the main diet for eight year olds (Fig. 32). In eight year olds in the upper Ottawa River mainly 9.79 percent Ephemeroptera, 7.90 percent Diptera, and 4.61 percent Hymenoptera were found.

Fig. 31. Changes in stomach contents of five and six year old mooneye (percent volume) in the lower and upper Ottawa River, 1977.

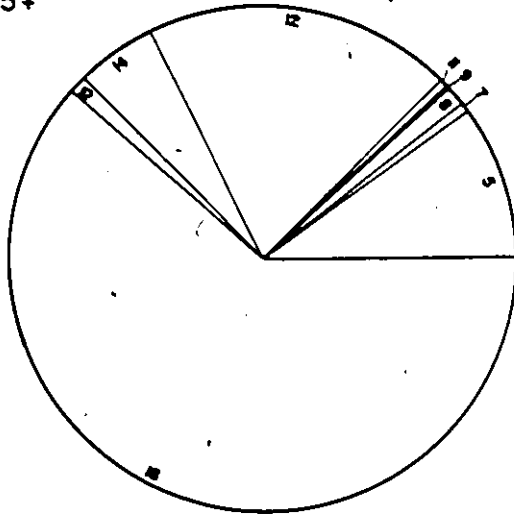
- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1977

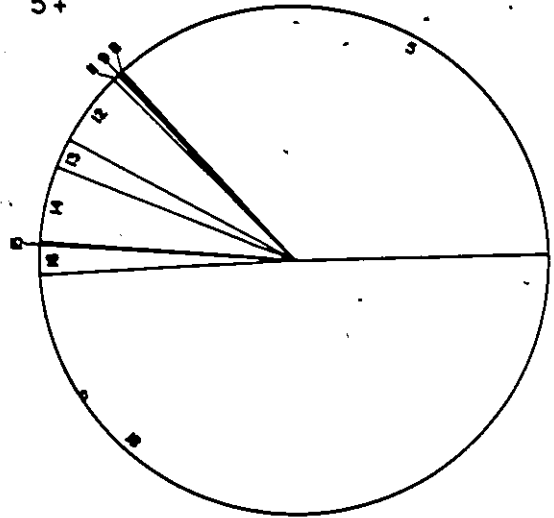
Upper river

Lower river

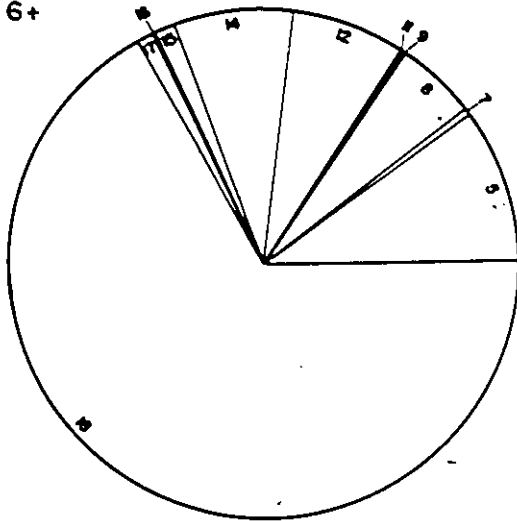
5+



5+



6+



6+

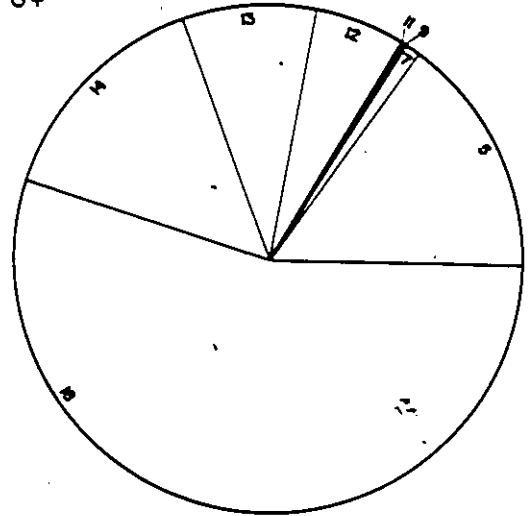


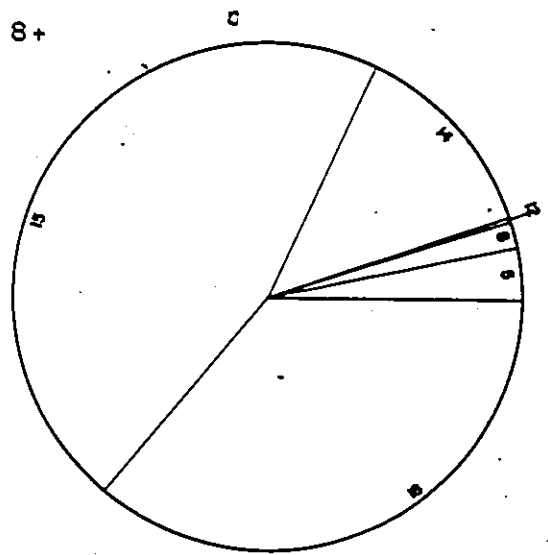
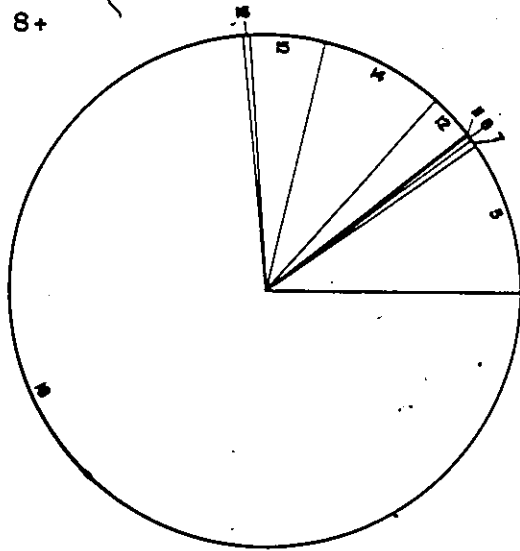
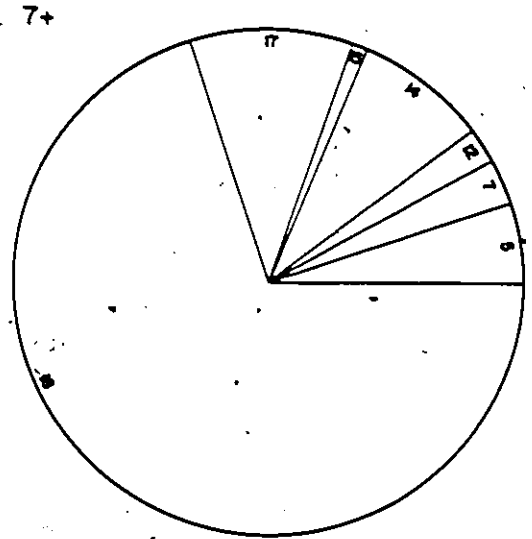
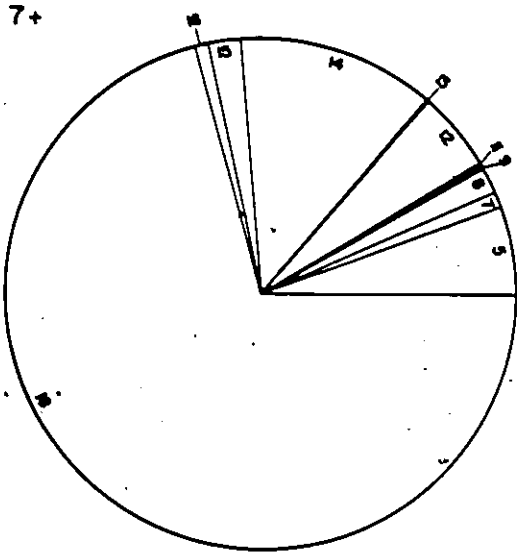
Fig. 32. Changes in stomach contents of seven and eight year old mooneye (percent volume) in the lower and upper Ottawa River, 1977.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1977

Upper river

Lower river



In the upper Ottawa River, 1977, the diet of nine to 12 year old mooneye consisted mainly of Diptera (13.24, 9.84, 26.73, and 11.79 percent respectively), Ephemeroptera (7.38, 14.37, 14.20, and 10.32 percent respectively) and Coleoptera (7.22, 3.10, 2.21 and 4.88 percent respectively) (Fig. 33).

The three methods used in stomach analysis, namely, numerical, frequency of occurrence, and volumetric, showed what mooneye ate in general. Each method, used alone, is biased in favor of food organisms resistant to digestion or to those of fairly large volume. Thus, definite conclusions can not be easily obtained from any one method. The three methods are generally used in many studies to overcome the various drawbacks of each method used individually.

#### Maturity and Fecundity

##### Sexual dimorphism

In the mature male, the anterior rays of the anal fin become extended and a distinct lobe is apparent (Fig. 34). In addition, a depression is noticed on the body opposite this fleshy lobe. Immature mooneye and adult females do not possess these unique characteristics. During the spawning season, mature males and females have a pinkish hue on their fins and bellies.

Fig. 33. Changes in stomach contents of nine, ten, eleven and twelve year old mooneye (percent volume) in the upper Ottawa River, 1977.

- |                  |                   |
|------------------|-------------------|
| 1. Pelecypoda    | 10. Hemiptera     |
| 2. Arachnida     | 11. Homoptera     |
| 3. Ostracoda     | 12. Coleoptera    |
| 4. Amphipoda     | 13. Tricoptera    |
| 5. Ephemeroptera | 14. Diptera       |
| 6. Odonata       | 15. Hymenoptera   |
| 7. Zygoptera     | 16. Formicidae    |
| 8. Orthoptera    | 17. Minnows       |
| 9. Plecoptera    | 18. Miscellaneous |

1977  
Upper river

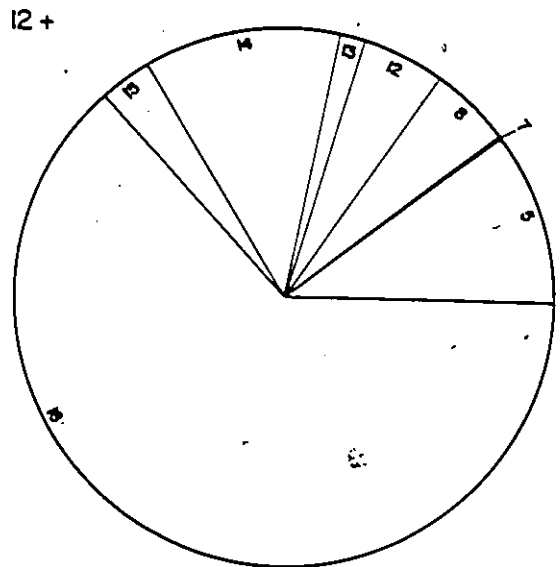
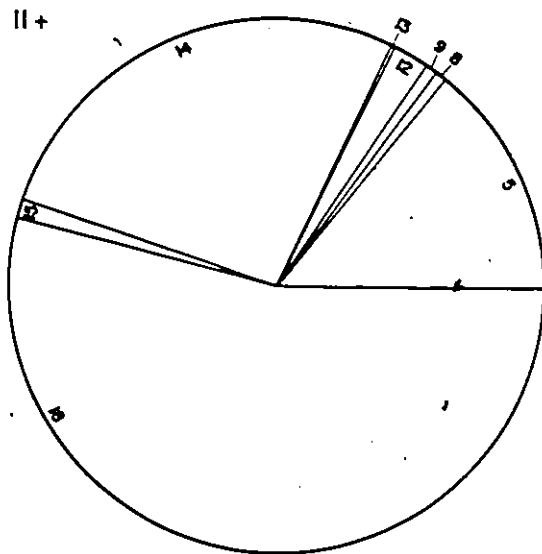
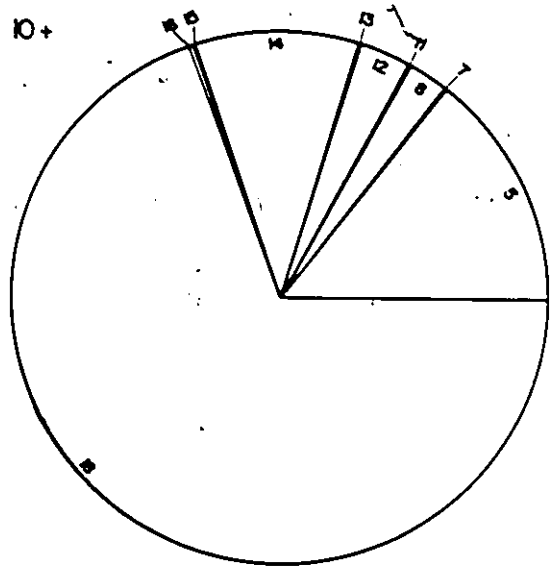
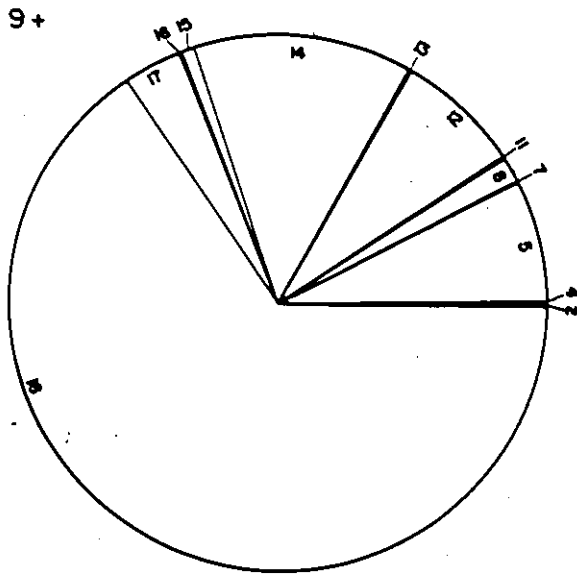
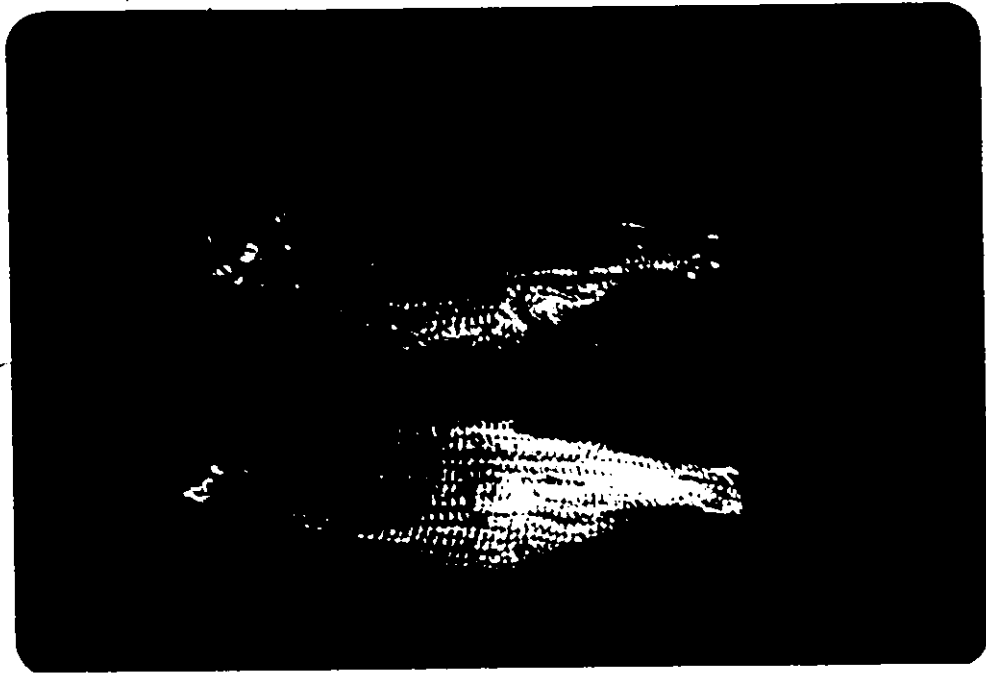


Fig. 34. Sexual dimorphism in male and female mooneye.



#### Sex ratio

Sex was determined for all fish (Table 18). Sex ratios varied at each age class, however, the overall sex ratio, female to male, for the lower and upper Ottawa River, is 2.2:1 and 3.4:1 respectively. These ratios do not change when they are determined for each month of the study (Table 19).

#### Sexual maturity

The number and percentages of females to males in both areas was determined for each age class (Table 20). In the lower Ottawa River, all females, aged one to three, were immature, while 71 percent were immature in their fourth year. All two year old males were immature

Table 18. Sex ratios at various ages of lower and upper Ottawa River mooneye in 1976-1977. Ratios are expressed in number and percentages.

Age	Lower River		percent F:M	Upper River		percent F:M
	Female	Male		Female	Male	
1	3	0	100:0	-	-	-
2	8	8	50:50	-	-	-
3	7	2	78:22	4	0	100:00
4	7	11	39:61	6	5	55:45
5	22	10	69:31	13	9	59:41
6	29	8	78:22	23	16	59:41
7	12	2	86:14	30	10	75:25
8	3	1	75:25	25	9	74:26
9				27	2	93:7
10				21	1	95:5
11				22	1	96:4
12				7	0	100:0
13				1	0	100:0
Total	91	42	68:32	179	53	77:23
Overall ratio		♀ ♂ 2.2.: 1			♀ ♂ 3.4 : 1	

Table 19. Number of female and male mooneye in each month during 1976-1977 in the Ottawa River. Sex ratios are expressed in both numbers and percentages.

Month	Lower River			Upper River		
	female N (ratio)	male N (ratio)	percent F:M	female N (ratio)	male N (ratio)	percent F:M
May	24 (2.7)	9 (1)	72:28	-	-	-
June	46 (2)	24 (1)	65:35	13 (6.5)	2 (1)	87:13
July	7 (2.3)	3 (1)	70:30	120 (3.2)	37 (1)	76:24
August	14 (2.3)	6 (1)	70:30	44 (3.4)	13 (1)	77:23
September	-	-	-	2 (2)	1 (1)	67:33

Table 20. State of sexual maturity at various ages for fish caught in the lower and upper Ottawa River, 1976-1977.

Age	Lower River						Upper River								
	Female			Male			Female			Male					
	Immature	Mature	%	Immature	Mature	%	Immature	Mature	%	Immature	Mature	%			
1	3	-	100	-	-	-	-	-	-	-	-	-	-	-	-
2	7	-	100	9	-	100	-	-	-	-	-	-	-	-	-
3	7	-	100	1	50	100	4	100	-	-	-	-	-	-	-
4	5	71	29	4	36	70	4	67	2	33	1	20	4	80	-
5	-	-	100	3	30	70	4	31	9	69	-	-	9	100	-
6	-	-	100	-	-	100	-	-	23	100	-	-	-	16	100
7	-	-	100	-	-	100	-	-	29	100	-	-	-	10	100
8	-	-	100	-	-	100	-	-	25	100	-	-	-	9	100
9	-	-	100	-	-	100	-	-	27	100	-	-	-	2	100
10	-	-	100	-	-	100	-	-	21	100	-	-	-	1	100
11	-	-	100	-	-	100	-	-	23	100	-	-	-	1	100
12	-	-	100	-	-	100	-	-	7	100	-	-	-	-	-
13	-	-	100	-	-	100	-	-	1	100	-	-	-	-	-
Total captured	22	68		17	26		12	167			1	52			
Percent of total captured	24	76		40	60		7	93			2	98			

in the lower Ottawa River while 50, 36, and 30 percent were immature in their third, fourth and fifth years, respectively. Thus, females mature at age four and males at age three in the lower Ottawa River.

In the upper Ottawa River, all females were immature at age three and 67 and 31 percent were immature at ages four and five. Twenty percent of males were immature in their fourth year. In the upper Ottawa River, both females and males mature at age four.

#### Fecundity

Total fecundity is best defined as the total number of eggs per ripe female while relative fecundity is the number of eggs per 100 g of body weight. The number of ripe females is very small so that only ranges are tabled (Table 21).

Table 21. Total and relative fecundity of mooneye for the lower Ottawa River, 1976-1977.

Age range	N	Total fecundity range	Mean total fecundity	Relative fecundity range	Mean relative fecundity
4 - 8	7	5000 - 9000	7375 ± 1288	1611 - 2651	2303 ± 435

Total fecundity was calculated as 7,375 eggs per female, while relative fecundity was determined at 2,303 eggs per 100 g of body weight.

#### Gonadosomatic Index

Gonadosomatic indices (GSI) were determined for each age

class on a monthly basis for mature female mooneye caught in the lower and upper Ottawa River in 1976-1977 (Table 22). The numbers in brackets represent standard deviations while those to the right of the brackets represent sample size. Generally, there is an increase in GSI's from one age group to the next and from month to month within each age group when spent females are considered.

The GSI's indicate that spawning occurs in May and June (Table 22). However, the spawning season, established by visual inspection of the gonads, occurs from mid-May to mid-June when the water temperature was 10-14° C. The beginning of the spawning season was determined by the first sign of spent females and running milt in mature males. Ripe females were not caught after the second week of June, signifying the end of the spawning season.

#### Egg diameter

A mean egg diameter of  $2.24 \pm .39$  mm (1.81 - 2.98 mm) was found for ripe mooneye caught in the lower Ottawa River during 1976-1977 (Table 23).

Table 22. Gonadosomatic Index for mature female mooneye in the Ottawa River in 1976-1977.

Location	Age	Month				
		May	June	July	August	September
lower Ottawa River	4	8.81( - )1	-	-	4.02( - )1	-
	5	4.24( .04)5	5.43( .09)12	1.69( - )1	5.31(1.36)4	-
	6	6.96( .05)7	4.62( .05)19	2.52( - )1	3.91( .15)2	-
	7	7.51( .05)3	5.38( .05)7	-	5.43(2.41)2	-
	8	9.96( - )1	1.70( - )1	-	8.01( - )1	-
	4	-	-	-	1.08( .04)2	-
	5	-	1.58( - )1	1.80( .25)5	3.97( .42)2	-
	6	-	1.07( - )1	2.28( .74)17	5.43(1.07)4	-
upper Ottawa River	7	-	1.28( - )1	2.80(1.11)19	5.89(1.61)2	-
	8	-	1.56( .29)4	2.80(1.50)16	5.00(2.06)5	-
	9	-	1.53( .14)3	2.76( .77)8	4.84(1.56)11	7.55( .19)2
	10	-	-	3.01( .68)10	5.56(1.96)5	-
	11	-	-	2.98( .99)14	4.96(1.11)8	-
	12	-	-	3.17(1.97)7	-	-
	13	-	2.39( - )1	-	-	-

Table 23. Egg diameters of twelve ripe mooneye from the Lower Ottawa River in 1976-1977.

Date	Egg diameter (mm)	Weight of females (g)
May 19, 1977	1.82	295.5
May 19, 1977	2.02	233.5
May 19, 1977	1.92	238.5
May 19, 1977	2.50	374.5
May 19, 1977	2.58	316.0
May 27, 1977	2.34	391.0
May 31, 1977	1.81	342.0
May 31, 1977	2.00	296.0
June 1, 1977	2.10	364.0
June 4, 1976	2.00	339.5
June 4, 1976	2.98	308.5
June 10, 1977	2.80	354.8
mean	2.24 ± .39	321.2 ± 50.0

#### Proximate Analysis

Protein, fat, and moisture analysis was done on fish muscle for three weight groups comprised of males and females (Table 24). There is no significant difference in percent protein, fat, and moisture between females and males in each weight class. The percent protein determined for females vary significantly ( $P \leq .05$ ) when considering the three weight classes. The percent protein ranges from 19.20 to 20.62 percent, the lipid content varies from 0.99 to 2.24 percent, and the moisture content ranges from 76.17 to 78.56 percent for all fish examined.

Table 24. Fish muscle analysis of the percent protein, fat, and moisture content of male and female mooneye in various weight classes from the Ottawa River. The mean and standard errors are given.

Weight class (g)	Number of males	Number of females	Percent protein		Percent fat		Percent moisture	
			♂	♀	♂	♀	♂	♀
0 - 250	5	5	19.20 ±.76	19.26 ±.46	1.26 ±.13	2.24 ±.54	78.56 ±.66	76.92 ±1.08
250 - 500	7	5	19.90 ±.24	20.52 ±.19	0.99 ±.21	1.10 ±.22	77.04 ±.58	76.22 ±.18
500 - 700	0	6	-	20.62 ±.32	-	1.30 ±.36	-	76.17 ±.33

## DISCUSSION

Generally, the growth of mooneye in the Ottawa River, both in length and in weight, was similar to growth of mooneye in Lake Erie and Lake St. Clair (Johnson, 1951; Van Oosten, 1961). Total length of fish three to seven years old ranged from 25.1 to 33.3 cm in these two areas as compared with 26.1 to 33.9 cm in the Ottawa River. Weight varied from 207.1 to 391.6 g in the Lake Erie, Lake St. Clair areas, while in the Ottawa River it ranged from 189.9 to 404.1 g for ages three to seven. Studies on mooneye in the Assiniboine River, Manitoba (Glen, 1975) indicate lesser growth than those found in the Ottawa River. It should be mentioned that in the Assiniboine River only estimated lengths and weights were reported so that observed lengths and weights would be somewhat higher. These estimates varied from 21.6 to 30.3 cm for length and 107 to 309 g for weight for fish ages three to seven years.

Genetic, physiological and environmental factors all affect growth rates. However, the most significant factor in affecting growth rate is population density (Carlander, 1977). Population density is dependent on food, space, predation, disease, competition for spawning sites, and cannibalism (Chapman, 1966). Slow growth and low condition factors are indicators of overpopulation. Furthermore, it is population density in relation to carrying capacity which more or less controls growth rates (Carlander, 1977). For instance, if biomass is well below carrying capacity, growth rates will be high and vice versa.

Upper Ottawa River mooneye have somewhat higher condition factors than those in the lower Ottawa River. Condition factors varied

from 1030.58 to 1039.67 for upper Ottawa River mooneye and from 941.23 to 983.06 for lower Ottawa River mooneye for fish ages four to seven years.

The high growth rates and condition factors of upper Ottawa River mooneye suggest that they have not exceeded the carrying capacity of this area. Mooneye in the lower Ottawa River have smaller growth rates and condition factors than those in the upper Ottawa River indicating that they may have surpassed the carrying capacity of that area and seem to be overpopulated.

Carrying capacity, in any system, is difficult to estimate. It is a function of food supply and habitat. It is generally accepted that the upper Ottawa River has a greater abundance of food and supports larger populations of fish and invertebrates than the lower Ottawa River (Rubec, 1975). This is also supported by studies in both areas of the Ottawa River on diversity and biomass of benthic invertebrates (Mackie, 1971; Qadri *et al.*, 1973).

The conditions affecting growth in the lower Ottawa River during both 1976 and 1977 were similar since significant differences in length and weight were not found (Fig. 2, 6, and 10). The same applies to the upper Ottawa River during both years (Fig. 3, 7, and 11). However, when comparing both areas in length and weight of fish significant differences were found (Fig. 4, 5, 8, 9, 12, and 13). It is most probable that growth is determined by general conditions, such as food availability, and population density. A possible explanation for the presence of Lee's phenomenon in backcalculated total lengths (Tables 5 to 8) was the selectiveness of the sampling techniques used. Five

gill nets, consisting of four gangs varying from 101.6 to 38.1 mm stretched mesh and another consisting of five gangs with stretched mesh ranging from 101.6 to 25.4 mm were used. These, in all likelihood, tended to select the larger fish of young age classes, and in all but one case, in the lower Ottawa River in 1977, young fish were not caught; this also occurred in goldeye studies (Martin, 1952). In addition to this, 85 out of 188 mooneye captured in the upper Ottawa River in 1977 were caught by angling just above the Deschênes Rapids. Angling and netting resulted in the catch of similar age classes (3 to 12 years old); however, the majority of mooneye caught by angling comprised older age classes. As well, they were not longer or heavier than those caught in the gill nets at any given age. In studies on goldeye, data were pooled independently of the type of catching gear used (Martin, 1952; Hill, 1966; Miller and Nelson, 1974).

Yearling mooneye exhibited less growth in length and weight than two year old fish in the lower Ottawa River (Fig. 14). Glen (1975) found that mooneye in the Assisiboine River younger than three years had smaller weight gains per unit length than older fish. In another study (1976), he found that growth of yearlings in July was similar to growth between August and November in the Assisiboine River. Similar data were reported for goldeye in Lake Clair, Alberta (Battle and Sprules, 1960).

The von Bertalanffy equation used in this study has various drawbacks. Some fish species undergo physiological transformations at some time in their life and change their ecological niche (Parker and Larkin, 1959). The Steelhead trout (Salmo gairdneri) and chinook salmon

(Oncorhynchus tshawytscha) exhibit very different growth rates in fresh and marine waters. In the case of the chinook salmon, the von Bertalanffy growth equation oversimplifies and underestimates the growth of an average fish in the population. In cases such as these, where both fresh water and marine environments come into play, growth must be considered in what Parker and Larkin termed growth stanzas for different stages of the species life history.

The equation assumes the existence of an ultimate length or asymptotic behaviour which, according to some researchers, is unacceptable because it is not universal phenomenon among fishes (Paloheimo and Dickie, 1965; Knight, 1968; and Roff, 1980).

The von Bertalanffy equation does, however, have its advantages. It is reasonably easy to calculate, is flexible and fits a wide range of data. Its use is justifiable on empirical grounds, and it permits comparison with other studies found in the literature (Ricker, 1958; Paloheimo and Dickie, 1965; Knight, 1969).

The von Bertalanffy growth model was used in this study because it was simple and provided an accurate description of the growth of mooneye. Mooneye are only found in fresh water and have a shorter lifespan as compared with fish that live beyond 50 years. In some specimens, ultimate length was attained thus justifying the use of the von Bertalanffy equation.

Mooneye fed mainly on insects. Similar diets have also been reported in other studies on mooneye (Boesel, 1938; Johnson, 1951; Glen, 1975) and on goldeye (Grosslein et al., 1959; Shelton, 1971, Cooper, 1973, Miller and Nelson, 1974). According to Boesel, mooneye

less than four cm in length ate zooplankton. This is also true of goldeye (Donald and Kooyman, 1977). Since mooneye less than 15 cm were not caught in this study it was impossible to clarify the previous statement. Glen (1975) found that young-of-the-year measuring more than ten cm consumed insects during their first winter. Scott (1967) and Trautman (1957) reported that adult mooneye ate fish. Glen (1975) found no evidence of this in the Assiniboine River, Manitoba. In the present study, five fish stomachs contained one minnow each while two others contained three and four minnows respectively. This indicated that mooneye ate fish sparingly. The same was true of goldeye (Cooper, 1973).

Spring and fall appeared to be the two main feeding periods for mooneye (Glen, 1975). Nothing has been published yet with respect to their feeding chronology. Angling in the upper Ottawa River was successful only at sunset when mooneye could be seen feeding on insects at the water surface. Studies on goldeye in the Fort Peck Reservoir, Montana, indicate that they do most of their feeding at night when food is available at the water surface (Cooper, 1973). The presence and consumption of certain food items by mooneye appeared to be related to their availability in the field (Johnson, 1951; Glen, 1975). In this study, food items consumed in large quantities from May to September corresponded to specific insect population peaks in the environment (Mackie, 1971). For instance, Ephemeroptera peaked in late May, beginning of June, and also in August in the upper Ottawa River. This corresponded to large quantities of Ephemeroptera consumed in the upper Ottawa river at these times.

Sexual dimorphism is present in mature mooneye. In mature males, the anterior rays of the anal fin become extended, thick, and fleshy (Fig. 34). In addition, there is a depression on the body adjacent to this fleshy lobe. Mature females do not possess these unique characteristics.

Female mooneye attained sexual maturity at four years of age in both areas of the Ottawa River (Table 20). In the lower Ottawa River, males matured one year earlier than females, while in the upper Ottawa River they reached maturity at age four, the same age as do females. This was similar to the findings of Glen and Williams (1976). They concluded that female mooneye matured in their fourth, fifth, or sixth year while males matured a year earlier than females. According to Johnson (1951), male mooneye in Lake St. Clair matured at age three and females became sexually mature by age five. Male goldeye mature at age three and females at age four (Grosslein *et al.*, 1959; Hill, 1966; Miller and Nelson, 1974).

Generally, sex ratios were biased toward females in each age class with the overall ratio for females to males being 2.2:1 and 3.4:1 for the lower and upper Ottawa River respectively (Table 18). Johnson (1951) found a 1:1 ratio during the first three years and an approximate 2:1 ratio in favor of females from ages four to eight.

According to Glen and Williams (1976) males have a shorter life span than do females. The oldest male caught in the Assiniboine River was seven years old and the oldest female was nine years old. Johnson (1951) reported males not older than seven years old with the maximum age of females being eight. In the lower Ottawa River, the

maximum age for both males and females caught was eight years old. In the upper Ottawa River, the oldest male caught was eleven years old while the oldest female was thirteen. In the goldeye population in Montana, the oldest male and female caught were five and eight years old respectively (Hill, 1966).

Spawning in the lower Ottawa River in 1977 occurred from mid-May to mid-June when water temperatures were approximately 10-14°C. This coincides with spawning in the Assiniboine River (Glen and Williams, 1976). In Lake Erie, mooneye begin to spawn in late April, early May, and finish around mid-June (Johnson, 1951).

The mean egg diameter of  $2.24 \pm 0.39$  mm for mooneye in the lower Ottawa River was similar to that reported in other studies. Egg diameter for mooneye in the Assiniboine River was 1.98 mm (Glen and Williams, 1976) while in Lake St. Clair the mean diameter was 2.0 mm (Johnson, 1951).

Fecundity for the lower Ottawa River mooneye ranged from approximately 5,000 to 9,000 eggs per female or 1,500 to 3,000 eggs per 100 g body weight (Table 21). These values were similar to those found for mooneye in the Assiniboine River (Glen and Williams, 1976). Johnson (1951) estimated the number of eggs for mooneye in Lake Erie to be between 10,000 and 20,000. The fecundity of goldeye ranges from 4,000 to 10,000 eggs per female (Hill, 1966). Scott (1962) studied the effect of diet on the number of eggs produced by trout while June (1970) correlated the fecundity of pike with water levels and temperature. Comparable studies describing the effects of physiological and environmental factors on egg production of mooneye have not yet been

conducted.

The Gonadosomatic Indices of mature mooneye increased throughout the summer months. This was consistent with Glen and William's (1976) findings for Assiniboine River mooneye. Another common trend was that the indices increased with age. Data during the winter months were not available in this study; however, Glen and Williams (1976) notices a decrease in the rate of increase in Gonadosomatic Indices after October as compared to the rapid increase from June to October. Since growth and reproduction are alternate activities in fish, it is possible that they stop feeding during gonad maturation before the onset of spawning (Woodhead, 1960).

The purpose of the proximate analysis was simply to establish if mooneye contained comparable amounts of protein, fat, and moisture, as other edible fish. The percent protein contained in the muscle of Cyprinus carpio, Esox lucius, Osmerus mordax, and Salvelinus namaycush was 24.4, 20.9, 15.9, and 18.4 percent respectively (Vinogradov, 1953; Love, 1970). The water content varied around 80 percent while that of lipid was approximately 2 percent for the species previously mentioned. The proximate analysis values for mooneye are very similar to the above values (Table 24). Therefore, mooneye appear to be as nutritious as any other edible fish.

The final aspect of this thesis was to ascertain whether mooneye could be considered a good game fish. In this respect, one must take into account both the angling and edibility aspects of mooneye. Fishing for mooneye on rod and reel with worms was similar to angling for bass. Goldeye (Hiodon alosoides), considered a delicacy in North

America is smoked in Winnipeg for commercial purposes. A simpler process could be used by individuals using the method put forth by Lantz and Iredale (1969). They also suggested baking goldeye, either fresh or previously frozen, in foil at 425°F for twenty minutes. The latter was considered the most satisfactory cooking method. Thus, mooneye would appear to be a very good sport and commercial fish and one which many could possibly turn to in the future.

## SUMMARY AND CONCLUSIONS

Various biological investigations were conducted on mooneye found in two areas of the Ottawa River near Ottawa, through June to October, 1976, and from May to September, 1977. The lower Ottawa River comprises the area from the Chaudière Falls to Lower Duck Island. The area from Aylmer Island to the Deschênes Rapids is designated the upper Ottawa River.

Difficulties were encountered in catching mooneye. Gill nets and angling were the only successful means of catching them. All other fishing methods proved unsuccessful. Even at that, only 197 and 235 fish were caught in the lower and upper Ottawa River respectively.

Scales proved to be the simplest and most convenient method of aging fish. Two other structures, namely otoliths and vertebrae were used to confirm the ages obtained from the scales. Comparison of ages obtained from the three structures gave a 93% agreement.

Generally, there are no significant differences between males and females in either area of the Ottawa River with respect to length, weight, and relative growth. However, upper Ottawa River fish were consistently longer and heavier in each age class than lower Ottawa River fish during 1976 and 1977 ( $P \leq .05$ ). In the lower Ottawa River, growth of mooneye in 1976 is not significantly different from growth in 1977. The same is true for upper Ottawa River mooneye. Condition factors were significantly different in the lower and upper Ottawa River only for fish ages four, five, and six.

Food consumed by mooneye consists of aquatic larvae and

nymphs, emergent adults, and terrestrial insects. The most important food items found are Ephemeroptera, Coleoptera, Tricoptera, and Diptera. The food items consumed coincide with the availability of these organisms in the field.

Sexual dimorphism is present in mooneye. Mature males are visually differentiated from females in that they possess a depression on the body adjacent to the fleshy lobe of the anal fin. This depression is clearly visible and has never been reported in the literature. Mature female and immatures do not possess any external sexual characteristics to differentiate them from males.

Female mooneye become sexually mature at four years and over in the lower and upper Ottawa River. Males mature one year earlier than females in the lower Ottawa River and at the same age as females in the upper Ottawa River. The overall sex ratios are biased toward females: 2.2:1 in the lower Ottawa River and 3.4:1 in the upper Ottawa River.

Fish older than eight years were not caught in the lower Ottawa River. In the upper Ottawa River, one 13 year old female was caught while the oldest male captured was 11 years old. These ages exceed by four years those previously reported for males and females.

Gonadosomatic indices increase with an increase in age. They also increase throughout the summer months. In the lower Ottawa River the GSI's peaked in May and June. Spawning occurred between mid-May and mid-June when water temperatures were between 10-14° C in the lower Ottawa River. Also, in the lower Ottawa River the mean egg diameter of pre-spawned females was 2.24 mm with total fecundity

ranging from 5,000 to 9,000 eggs per female.

Proximate studies of mooneye muscle revealed a protein content comparable to that of other fishes; significant differences in protein values were not noted between males and females of various weight classes.

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Appendix 1. Stomach analysis. Dates of capture in the lower Ottawa River, 1976. Fish with empty stomachs are not included.

Date	Age				
	4	5	6	7	8
June 2	2	5	7	1	2
3	2	2	4	1	1
4	-	6	8	4	-
8	-	2	4	-	1
19	-	-	1	-	-
22	1	3	1	-	-
23	-	-	4	-	-
24	1	-	-	-	-
25	-	1	-	-	-
30	1	-	-	1	-
Subtotal	7	19	29	7	4
July 14	1	-	-	-	-
Subtotal	1	-	-	-	-
August 17	1	-	-	-	-
18	-	1	-	1	-
Subtotal	1	1	-	1	-
Total	9	20	29	8	4

Appendix 2. Stomach analysis. Dates of capture in the upper Ottawa River, 1976. Fish with empty stomachs are not included.

Date	Age									
	4	5	6	7	8	9	10	11	12	
July 7	-	5	2	6	1	1	-	3	1	
8	-	-	3	2	6	1	3	1	1	
Subtotal	-	5	5	8	7	2	3	4	2	
August 10	1	-	-	1	2	1	1	4	-	
Subtotal	1	-	-	9	2	1	1	4	-	
Total	1	5	5		9	3	4	8	2	

Appendix 3. Stomach analysis. Dates of capture in the lower Ottawa River, 1977. Fish with empty stomachs are not included.

Date	Age							
	1	2	3	4	5	6	7	8
May 19	2	3	1	6	4	5	-	-
20	-	-	-	-	-	1	-	-
27	-	-	-	-	-	-	-	1
31	-	-	1	-	1	2	3	1
Subtotal	2	3	2	6	5	8	3	1
June 1	1	-	1	-	2	-	1	-
10	-	-	-	1	-	-	1	-
22	-	-	-	-	-	1	1	-
23	-	4	1	2	2	1	-	-
24	-	-	-	-	1	3	-	1
30	-	3	1	-	-	-	-	-
Subtotal	1	7	3	3	5	5	3	1
July 9	-	3	2	-	2	1	-	-
10	-	-	1	-	-	-	-	-
Subtotal	-	3	3	-	2	1	-	-
August 17	-	-	-	-	2	-	-	-
18	-	-	-	-	1	-	-	-
19	-	-	-	2	-	1	-	-
20	-	2	1	1	1	1	1	-
26	-	1	-	-	-	1	-	1
Subtotal	-	3	1	3	4	3	1	1
Total	3	16	9	12	16	17	6	3

Appendix 4. Stomach analysis. Dates of capture in the upper Ottawa River, 1977. Fish with empty stomachs are not included.

Date		Age										
		3	4	5	6	7	8	9	10	11	12	13
June	11	-	-	2	1	1	3	3	-	-	-	-
	14	-	1	2	-	-	1	-	-	-	-	-
	15	-	-	-	-	-	-	-	-	-	-	1
	Subtotal	-	1	4	1	1	4	3	-	-	-	1
July	4	-	-	2	-	1	4	-	-	1	-	-
	5	-	1	-	2	-	1	1	-	-	-	-
	6	-	-	-	3	2	-	-	-	1	-	-
	7	-	-	2	-	2	2	2	-	-	1	-
	10	1	-	3	3	1	-	-	1	4	-	-
	11	-	-	-	-	2	1	-	2	1	-	-
	12	-	1	-	1	-	-	-	-	-	-	-
	13	-	-	1	1	-	1	-	-	-	-	-
	14	-	-	-	1	2	-	-	-	-	-	-
	18	-	-	1	2	1	-	1	-	1	-	-
	19	2	2	-	3	2	1	1	-	-	-	-
	21	-	2	-	3	9	3	1	2	1	1	-
	22	1	1	-	4	3	3	3	4	1	3	-
	Subtotal	4	7	9	23	25	16	9	9	10	5	-
August	9	-	-	-	-	1	-	5	-	1	-	-
	10	-	1	2	1	1	1	2	5	1	-	-
	11	-	-	-	-	1	-	1	1	-	-	-
	12	-	-	-	-	-	-	2	-	-	-	-
	23	-	1	-	1	-	-	-	-	-	-	-
	24	-	-	-	1	-	-	-	-	-	-	-
	25	-	-	-	-	-	2	-	1	-	-	-
	26	-	-	-	4	1	-	1	-	1	-	-
Subtotal	-	2	2	7	4	3	11	7	3	-	-	
September	8	-	-	1	-	-	-	2	-	-	-	-
	Subtotal	-	-	1	-	-	-	2	-	-	-	-
Total		4	10	16	31	30	23	25	16	13	5	1